MACHINE DESIGN

THE FASTENERS BOOK

anual for design engineers

What this Book contains . . . . . .

- Design Data Section, Page 5

  Basic design information on twenty key fastener subjects:

Terminology	Studs	Small Rivets
Standards	Locknuts	Quick-Operating Fasteners
Screw Thread Forms	Washers	Retaining Rings
Materials	Set Screws	Blind Rivets
Finishes and Coatings	Sealing Fasteners	Fastener Vibration
Joint Design	Weld Fasteners	Fastener Evaluation
Tapping Screws	Pin Fasteners	

- Product Directory Section, Page 96

  Detailed information on available fastener types in eight categories:

Inserts	Quick-Operating Fasteners	Screws, Bolts, Studs
Nuts	Retaining Rings	Washers
Pin Fasteners	Rivets	

- Alphabetical listing of companies in the United States that manufacture fasteners of these eight types, coded by product

- Alphabetical listing of tradenames of fasteners in these eight categories

For a more detailed listing of subjects, see Contents, Pages 2-4

The FASTENERS Book

MACHINE DESIGN

This Book has one main purpose: To provide direct answers to fastener problems in design. Its pages contain information on both design practices and commercially available products. The Book is arranged in easy-reference chapter form to speed and simplify its use on the job.

In the Design Data Section, topics of general importance are presented first, followed by recommendations on specific problem areas. The Product Directory Section is set up in chapters according to product category. In each chapter editorial and advertising pages have been integrated and cross-referenced to provide complete, self-contained information packages.

Although all fastener types may not be covered, practices and products that are presented here apply to the vast majority of problems encountered in design.

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MACHINE DESIGN

The Fasteners Book

Design Data Section

A basic guide to selection, specification, and application of fasteners in design.

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DESIGN DATA

CHAPTER 1

Terminology

TECHNICAL INFORMATION STAFF
Industrial Fasteners Institute, Cleveland, Ohio

Fasteners presently available offer virtually an infinite number of types, sizes, and characteristics to match the wide range of design requirements.

Almost matching this diversity are the specialized terms associated with these products, their specification, and manufacture. This glossary is presented as an aid to proper specification of fasteners or fastener details.

BASIC TERMS

Acme screw threads. A translating thread form. Sometimes used in fasteners where special characteristics of thread are advantageous.

Aircraft quality fastener. A fastener designed and manufactured for highly stressed application. They are produced under closely controlled, restricted methods of manufacture.

American National Thread Standards. Standards which once defined the basic fastener thread forms in the United States. Now superseded by the United Thread Standards.

Bearing area. The projected area of a rivet, bolt, or other fastener subjected to bearing load against the wall of the hole. It equals diameter of fastener multiplied by thickness of thinnest plate in the joint.

Bearing face or surface. The supporting surface of a fastener with respect to the part it fastens or mates. The underside of a bolt head or nut.

Blind rivet or bolt. A fastener which can be inserted and driven from one side of the work. The head is formed on the far blind side by manipulation of the fastener from the front.

Blunt start. Starting end of screw in which a partial thread has been removed. Used on threaded parts which are assembled repeatedly by hand.

Body. The unthreaded portion of the shank of a threaded fastener.

Body, externally relieved. Fastener body in which diameter is reduced to less than the minimum pitch diameter of the thread.

Body, internally relieved. A fastener with an axial hole drilled through a portion of the body to relieve stresses under load.

Body, reduced diameter. Fastener body with diameter equal to or greater than minimum pitch diameter of thread but not greater than minimum major diameter of the thread. This definition applies primarily to externally threaded parts with rolled threads.

Bolt. An externally threaded, headed fastener. The traditional distinction between a bolt and a screw is that a bolt is usually used in a through hole with a mating nut while a screw is generally used in a threaded hole without a nut. Current usage, however, tends to steer away from this distinction, leaving no clear cut dividing line between the two fasteners, except as they are defined arbitrarily.

British Association Standard Threads. A small screw thread form used in clock making and instrument work.

Buttress thread. A translating thread form capable of withstanding high stresses in one direction only. The thrust side of the thread forms an angle of 7 deg with a line perpendicular to the axis. Sometimes used in threaded fasteners to meet special application requirements. Radial stress in a lubricated tightened nut is practically nil.

Class, Thread. System used to identify the class of fit of the thread. Class of unified threads is identified by numerals followed by letter A or B to designate external or internal threads, respectively. Each thread class represents specific tolerance requirements. In general, the higher the thread class number, the closer the fit.

Threaded Fastener Head Styles

Ball

Used for special purposes on machine screws only.

Binding

Undercut binds and eliminates fraying of wire in electrical work. Ample bearing surface. Used for machine screws, available with slotted or Phillips driving recess.

Button

Used for bolts and cap screws. Bolt head has no driving recess, cap screw has hexagon socket recess.

Fillister

Smaller in diameter than round head, but has higher, deeper slot. Can be used in counterbored holes. Available with slotted or Phillips driving recess for machine screws, tapping screws and cap screws.

Flat Fillister

Similar to standard fillister but without oval top. Used in counter bored holes that require a flush screw. Available with slot only for machine screws.

Flat, 82 deg

Use where flush surface is desired. Countersunk section aids centering. Available with slotted, clutch, Phillips, or hexagon-socket driving recess. Also available with no recess for metal drive screws.

Flat, 100 deg

Larger head than 82-deg design. Use with thin metals, plastics, etc. Available with slotted or Phillips driving recess.

Flat Trim

Similar to 82 deg flat head except depth of countersink has been reduced. Available in Phillips driving recess only.

Flat Undercut

Standard 82 deg flat head with lower 1/3 of countersink removed for production of short screws. Permits flush assemblies in thin stock. Available with slotted or Phillips driving recess.

Headless

Used for set screws only. Available with slotted, hexagon-socket, or fluted-socket driving recess.

Hexagon

Standard head for machine bolts and screws. Has square, sharp corners, ample bearing surface for wrench tightening. This head also available for tapping screws.

Hexagon Washer

Same as Hexagon except with washer section at base to protect work surface against wrench disfigurement. Used for machine screws and tapping screws.

Oval

Similar to standard flat head. Has outer surface rounded for added attractiveness. Available in slotted, Phillips or clutch driving recess.

Oval Trim

Similar to oval heal except depth of countersink is reduced. Available with Phillips driving recess only.

Oval Undercut

Similar to flat undercut. Has outer surface rounded for appearance. Available with slotted or Phillips driving recess.

Pan

Low large diameter with high outer edges for maximum driving power. Available with slotted or Phillips recess for machine screws and cap screws. Available plain for driving screws.

Round

For general-purpose service. Has good slot depth, ample bearing surface. Used for bolts, machine screws, cap screws, tapping screws and drive screws. Available with slotted or Phillips driving recess. Available with no recess for driving screws.

Round Countersunk

Used for bolts only. Similar to 82 deg flat head except it has no driving recess.

Round Washer

Integral washer for bearing surface. Covers larger bearing area than round or truss head. Used for tapping screws only; available with slotted or Phillips driving recess.

Square (bolt)

Generous bearing surface for wrench tightening.

Square Countersunk

Used on plow bolts, which are used on farm machinery and heavy construction equipment.

Square (Set-Screw)

Can be tightened to higher torque than any other set-screw head.

T-Head

Available for bolts. Used in the machine tool industry. T-head can be inserted in a T-slot in a tool bed, then turned 90 deg for clamping purposes.

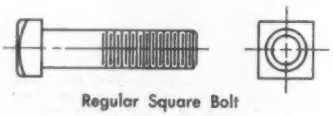
Truss

Similar to round head, except head is shallower and has a larger diameter. Good for covering large diameter clearance holes in sheet metal. Available for machine screws and tapping screws in slotted, clutch, or Phillips driving recess.

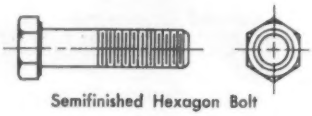
Twelve-point

A double hexagon head used extensively in the aircraft industry because of its low weight to strength ratio and superior adaptability to pneumatic wrenching. Available for bolts and machine screws.

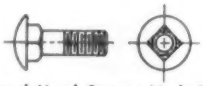
Standard Bolt Styles

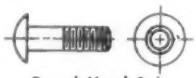

Regular Square Bolt

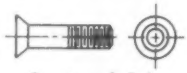
Hexagon Bolt

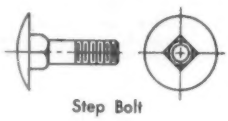

Semifinished Hexagon Bolt

Finished Hexagon Bolt


Round Head Square Neck Bolt
(Square Neck Carriage Bolt)

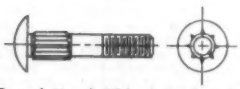

Round Head Bolt
(Button Head Bolt)

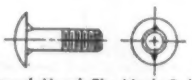

Countersunk Bolt

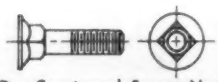

Step Bolt

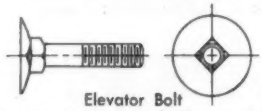
T-Head Bolt

Round Head Short
Square Neck Bolt

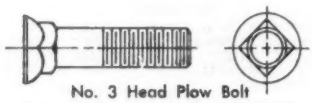

Round Head Ribbed Neck Bolt
(Ribbed Neck Carriage Bolt)


Round Head Fin Neck Bolt
(Fin Neck Carriage Bolt)


114 Deg Countersunk Square Neck Bolt
(Countersunk Carriage Bolt)


Elevator Bolt
(Flat Head Countersunk Elevator Bolt)

Elevator Bolt
(Ribbed Head Elevator Bolt)

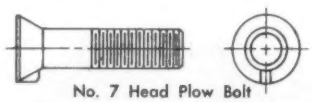

No. 3 Head Plow Bolt
(Round Countersunk Square Neck)

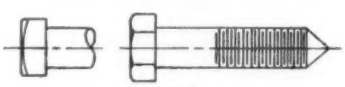
No. 4 Regular Head Plow Bolt
(Square Head Countersunk)

No. 4 Repair Head Plow Bolt
(Square Head Countersunk)

No. 6 Regular Head Plow Bolt
(Round Countersunk Heavy Key)

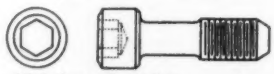
No. 6 Repair Head Plow Bolt
(Round Countersunk Heavy Key)

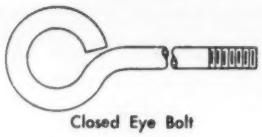

No. 7 Head Plow Bolt
(Round Countersunk, Reverse Key)

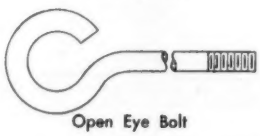

Joint Bolt

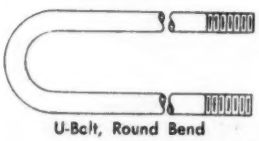
Oval Neck Track Bolt

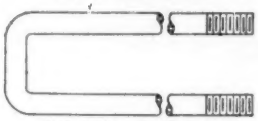
Elliptic Neck Track Bolt

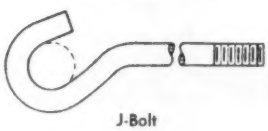

High-Strength High-Temperature
Internal Wrenching Bolts

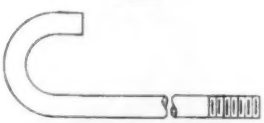

Closed Eye Bolt

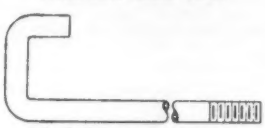

Open Eye Bolt

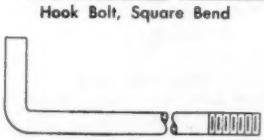

U-Bolt, Round Bend

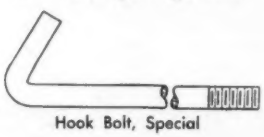

U-Bolt, Square Bend


J-Bolt


Hook Bolt, Round Bend


Hook Bolt, Square Bend


Hook Bolt, Right Angle Bend


Hook Bolt, Special

Complete thread. That part of the thread having full form at both crest and root. Also, to identify threads which extend the full distance of the specified fastener thread length.

Crest. The outermost tip of a male thread as seen in a thread profile, or the innermost tip of a female thread.

Decarburized fastener. A fastener with lower carbon content on the surface than at the core.

Depth of thread. The distance between the major and minor thread radii.

Depth of thread engagement. The distance two mating thread forms overlap, or the difference between the major radius of the male thread and the minor radius of the female thread.

Diagonal pitch, rivet. Distance between centers of rivets in adjacent rows when staggered or when zigzag riveting is used.

Drive screw. A fastener designed with an extremely fast lead thread which permits it to be pressed or hammered into place without the necessity of torquing.

Driver head. An obsolete term applied to a tool head, other than a wrench, designed for driving a threaded fastener.

Driving recess. The cutaway portion of the bolt or screw head which is shaped to accept a driving tool.

Effective thread. Useful thread. Includes the complete thread and that portion of the incomplete thread having fully formed roots.

External thread. A thread on the external surface of a cylinder or cone. Often referred to as the male thread.

External wrenching. A bolt or nut type designed to be assembled by a wrench applied to its external surfaces.

Faying surface. The bearing surface of a bolt or nut face, surface of a joint.

Finished fastener. A fastener made to close tolerances and having surfaces other than the threads and bearing surface finished to provide a general high-grade appearance.

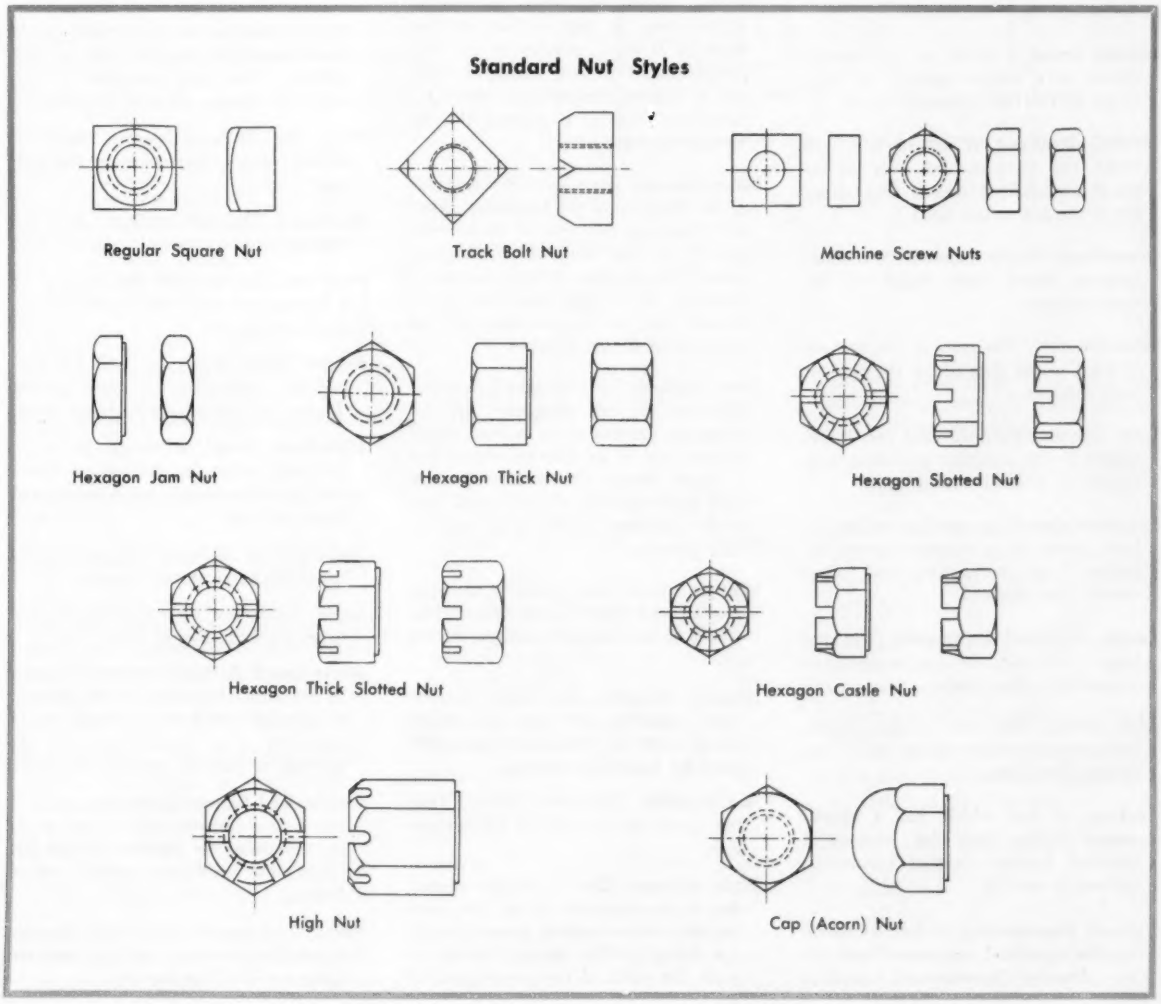
Finished series. Nuts for normal use. Are generally thinner than heavy series nuts.

Flank, thread. The thread surface connecting the crest with the root.

Full Series. All nuts and bolt head with same across-flats and thickness dimensions as regular series. Nonstandard term.

Gage line, rivet. A centerline drawn parallel to the joint edge of the plates.

Hammer, riveting. A portable pneumatic hammer used to set solid rivets. One-shot, slow-hitting type (900 to 2500 blows per minute) is most widely used. Fast-hitting type (3000 to 5000 blows



per minute) is harder to control.

Head locking fastener. A fastener designed with some means of locking the screw head in place.

Heavy Series. Bolts and nuts for heavy loads and holes with large head clearances. Bolt heads and nuts of this series are thicker and wider than regular series.

Height of thread. Same as Depth of Thread.

Helix angle. The angle made by the helix of a thread at the pitch diameter with a plane perpendicular to the axis of the screw.

Incomplete thread. On a straight thread, an incomplete thread is that portion having roots not fully formed by the lead or chamfer of the threading tools.

Insert. Basically a special form of nut to serve function of tapped hole in blind or open locations. May be used to provide high-strength threads in soft materials, a threaded hole with locking features, or a thread anchor in materials where tapping is impractical.

Internal thread. A thread on the internal surface of a hollow cylinder or cone. Often referred to as female thread.

Internal wrenching. A nut or bolt type which can be assembled with an internal wrench by means of a socket on top of the nut or bolt head.

International Metric Standard. A general-purpose thread form based on the metric system.

Joint efficiency. The ratio of the strength of joint to the strength of the weakest joint member.

Lead. The distance a threaded part moves axially in one complete revolution with respect to a fixed mating part.

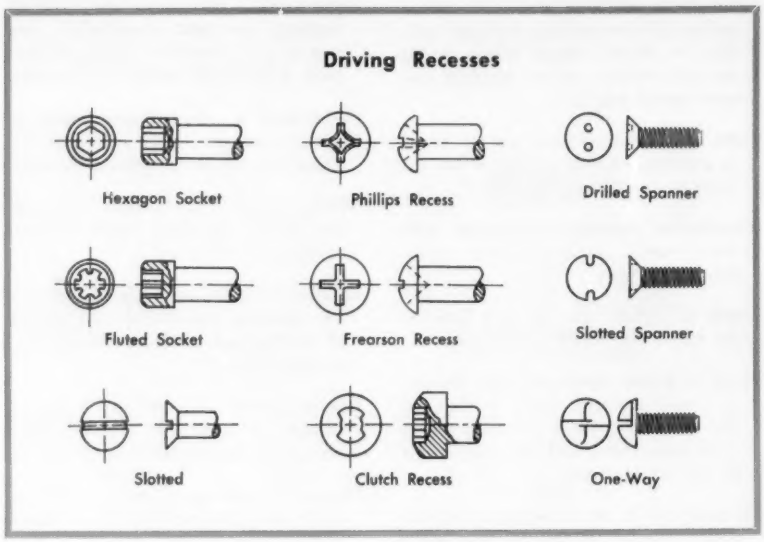
Left-hand thread. A thread in which the helix winds in a counterclockwise direction from the starting end, when viewed from that end.

Length of thread engagement. The distance that one part is engaged, or screwed into the other.

Light Series. Nuts with smaller across-flats dimension than regular series nuts. Nonstandard term.

Locknut. A nut which has a special means within itself for gripping a threaded fastener so that rotation is resisted in service.

Locknut, Free-spinning. A locknut which can be assembled or turned freely on the threaded fastener and develops locking action only after being tightened against a base surface.



Locknut, prevailing-torque. A locknut which locks at any position on the threaded fastener, whether or not it is seated against a base surface. Usually has a locking element that resists rotation as soon as it engages the externally threaded part.

Major diameter. For a straight thread this is the diameter of the imaginary cylinder bounding the crest of an external thread or the root of an internal thread. For a taper thread, the major diameter, in a given position on the thread axis, is the diameter of the major cone at that position.

Minor diameter. For a straight thread, this diameter is the imaginary cylinder bounding the root of an external thread or the crest of an internal thread. For a taper thread, the minor diameter, in a given position on the thread axis, is the diameter of the minor cone at that position.

Multiple thread. Also called a multiple-start thread, this thread has a lead which is an integral multiple of the pitch.

Nominal diameter. The basic diameter that establishes the size and dimensional limits of threaded or unthreaded parts for assembly purposes.

Nut thickness. The over-all distance from the top of the nut to the bearing surface.

Pitch diameter. For a straight thread, this is the diameter of the imaginary cylinder whose surface passes through the thread profiles in such a way to make the width of the groove equal to one-half the basic pitch. For a perfect thread, this occurs where the widths of the thread and groove are equal. For a taper thread, the pitch diameter in a given position on the thread axis is the diameter of the pitch cone at that position. The pitch diameter is also known as simple effective diameter.

Pitch, rivet. Distance between centers of adjacent rivets measured along the gage line.

Proof load. The specified load which the fastener must withstand in a proof test.

Proof test. Any specified test required of a fastener to verify its suitability for the fastening job.

Regular Series. Bolts and nuts for normal use. Bolt heads and nuts that are thinner and narrower than heavy series.

Right-hand thread. A thread in which the helix winds in a clockwise direction from the starting end when viewed from that end.

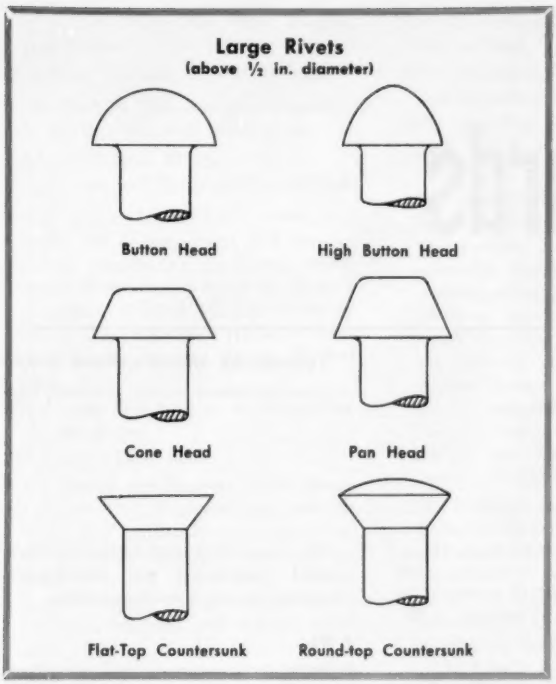
Root. Identical with the cylinder or cone from which the thread projects.

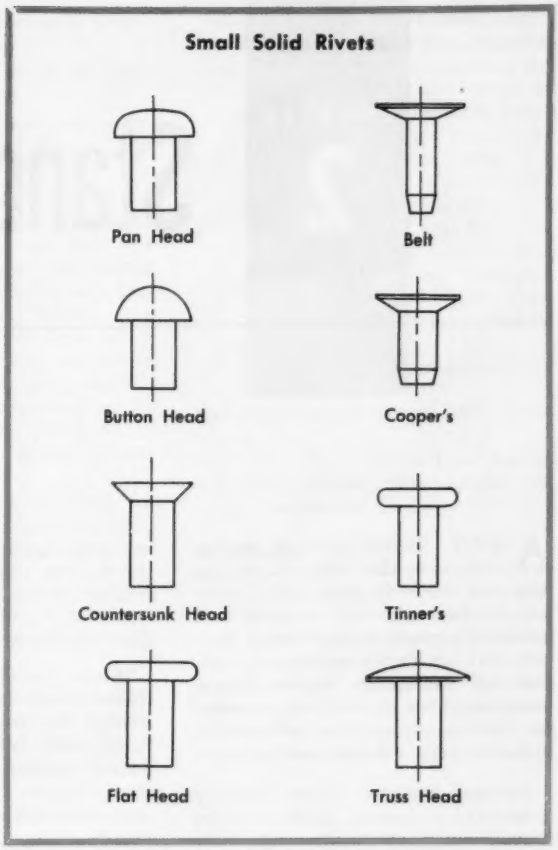
Screw. Externally threaded, headed fastener. See definition of bolt.

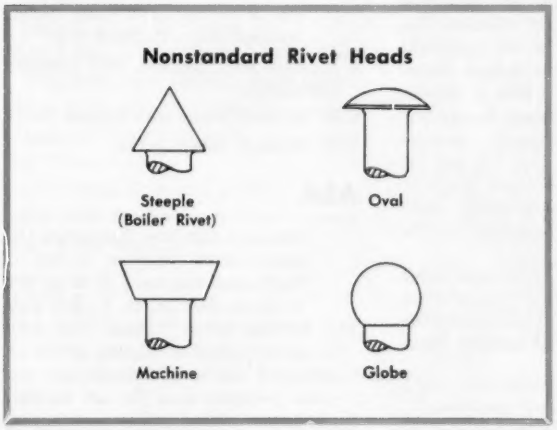
Screw thread. A ridge of uniform section in the form of a helix on the external or internal surface of a cylinder, or in the form of a conical spiral on the external or internal surface of a cone.

Semifinished fastener. A fastener made to the same relatively wide tolerances as an unfinished or regular fastener but having the underhead bearing surface finished.

Shank. That portion of a headed fastener which lies between the head and the extreme end of the fastener.







Simple effective diameter. See pitch diameter.

Single thread. A single or single-start thread has a lead equal to the pitch.

Stove bolt. Generally defined as a regular machine screw with a machine-screw nut. Sometimes defined as a regular machine screw with a square "stove bolt" nut. Term is becoming obsolete.

Tapping screws. Hardened thread screw that cuts or forms its own thread in an untapped hole.

Thread form, basic. The theoretical profile of the thread for a length of one pitch in an axial plane.

Thread pitch. The distance along the thread axis between corresponding points on adjacent thread forms, or, the distance from the crest of one thread to the crest of another. Pitch is the reciprocal of the number of threads per inch.

Thread series. There are eleven standard series of threads, classified and distinguished by the number of threads per inch on a given diameter. They are: Coarse-thread series, fine-thread series, extra-fine-thread series, 4-thread series, 6-thread series, 8-thread series, 12-thread series, and the 16-thread series, 20-thread series, 28-thread series, and the 32-thread series.

Torquing. The act of tightening a fastener to some specified torque value.

Total thread. Includes the complete or effective thread and the incomplete thread.

Transverse pitch, rivet. In a joint with two or more rows of rivets, the distance between gage lines.

Turns per inch. The reciprocal of the lead in inches.

Unified Thread Standards. A set of thread standards agreed upon by the United States, the United Kingdom, and Canada.

Unfinished fastener. A fastener made to the same basic dimensions as a finished fastener but having relatively wide tolerances and all surfaces in their formed condition.

Washer face. A circular boss on the bearing surface of a bolt or nut.

Whitworth Standard Thread. A thread form in declining use in the United Kingdom.

Wrenching head. An obsolete term applied to a head having provision for driving by means of a wrench.

DESIGN DATA

CHAPTER 2

Standards

TECHNICAL INFORMATION STAFF
Industrial Fasteners Institute, Cleveland, Ohio

ABOUT 500,000 standard fastener items can be identified by name, type, size, and material. Each such fastener can be referenced directly to one or more published standards or specifications. Actually there are literally hundreds of standards and specifications defining fastener properties. These publications are issued by technical organizations and societies, industry groups, and individual companies.

National Standards: These cover the properties of fastener products having broad usage by several consuming industries. Such standards are normally developed under democratic standardization procedures, with all interested parties, both manufacturer and user, having full opportunity to participate. National standards are issued by standardization organizations and technical societies which serve many interests, administer a wide variety of standardization activities, and retain an attitude of impartiality.

Industry Standards: Prepared and distributed by organizations performing standardization work in specialized fields, these standards are usually limited in scope; they are normally patterned more to suit specifics than generalities. The development of such standards are basically unilateral, with acceptance of other interested parties being solicited only after the preparing agency is well satisfied with the workability of the standard.

General acceptance by a recognized national standardization group is usually sought by submitting the standard with a request for its adoption. Before an industry standard can be promoted to national recognition, it is necessary to offer it for comment to all interested parties. Usually many revisions, refinements, additions and other changes are made before acceptance is gained.

Company Standards: Independent producers or users issue these standards to cover their own particular requirements. Producers of proprietary items, specialties, and other patented fasteners must, of necessity, issue their own standards. Such standards seldom are offered or would be considered for adoption as industry or national standards.

Military Specifications: Military specifications and standards are developed through the co-ordinated efforts of the Army, Navy, and Air Force, under the general direction of the Armed Forces Supply Support Center, Office of the Assistant Secretary of Defense, Supply and Logistics. They are primarily intended for use by the various branches and departments within the military establishment. However, they have certain application outside of the Department of Defense.

Listed here are many of the basic standards and specifications from various standardizing groups as well as sources of availability. Only national and industry standards are included.

AAR

Association of American Railroads, 59 East Van Buren St., Chicago 5, Ill.

M-110 Rivet Steel and Rivets.

M-125 Machine Bolts and Nuts, Heat-Treated Carbon-Steel and Alloy-Steel Track Bolts.

ABS

American Bureau of Shipping, 45 Broad St., New York 4, N. Y.

Rules for Building and Classing Steel Vessels. Covers dimensional, material, and design requirements for steel rivets.

AMS

Aeronautical Material Specifications Div., Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.

Aeronautical Material Specifications. Material and process specifications for aircraft components conforming to established engineering and metallurgical practices in the aircraft industries.

API

American Petroleum Institute, Division of Production, 816 Rio Grande National Bldg., Dallas 2, Tex.

4 Standard Rigs, Derricks, and Accessory Equipment.

12-A Standard Tanks with Riveted Shells.

12-B Standard Bolted Tanks.

ASA

American Standards Association, Obtained from *American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.*

B1.1 Unified Screw Threads. The bible on screw threads, it includes all the dimensional features, formulation and other pertinent data for all standard and special pitch-diameter combinations in all series of Unified screw threads in the size range from 0.060 to 6-in. diameter. Similar data are also given in appendix form for the now obsolete American National thread series.

B1.2 Screw Thread Gages and Gaging. Gives recommended gage practices and gage tolerances for screw thread gages.

B1.4 Screw Threads for High-Strength Bolting.

B1.5 Acme Screw Threads.

B1.8 Stub-Acme Screw Threads.

B1.9 Buttress Screw Threads.

B1.10 Unified Miniature Screw Threads. A new standard that introduces a screw thread series covering the diameter range from 0.018 to 0.0551 in.

B1.12 Class 5 Interference-Fit Thread. A trial standard which details dimensions of a newly designed interference-fit thread.

B2.1 Pipe Threads.

B4.1 Limits and Fits for Engineering and Manufacturing (Part 1).

B5.1 T Slots: Their Bolts, Nuts, Tongues, and Cutters.

B5.4 Taps, Cut and Ground Threads.

B5.20 Machine Pins. Includes dimensions of dowel, clevis, and cotter pins.

B18.1 Small Solid Rivets.

B18.2 Square and Hexagon Bolts and Nuts.

B18.3 Socket Head Cap Screws and Socket Set Screws. There is a new industry standard for socket cap screws which is expected to form the basis of a revision of B18.3. Copies of the industry standard are available from: *Socket Screw Products Bureau, 53 Park Place, New York 7, N. Y.*

B18.4 Large Rivets: ½-in. nominal diameter and larger.

B18.5 Round Head Bolts.

B18.6 Slotted and Recessed Head Screws. Issued in 1947, it covered cap, machine, wood, and tapping screws. Since then it has been superseded in part by B18.6.1, B18.6.2, and B18.6.4. A new standard which covers machine screws has been finalized and will be issued soon.

B18.6.1 Slotted and Recessed Head Wood Screws.

B18.6.2 Cap and Set Screws.

B18.6.4 Slotted and Recessed Head Tapping Screws and Metallic Drive Screws.

B18.8 High-Strength High-Temperature Internal Wrenching Bolts.

B18.9 Plow Bolts.

B18.10 Track Bolts and Nuts.

B27.1 Lock Washers.

B27.2 Plain Washers.

ASTM

American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

Book of Standards, Part 1. A triennial publication which includes supplements issued in intervening years. Part 1 covers all specifications and standards on products of ferrous metals.

A29 General Requirements for Hot-Rolled and Cold-Finished Carbon and Alloy Steel Bars.

A31 Boiler Rivet Steel and Rivets.

A65 Soft Steel Track Spikes.

A66 Steel Screw Spikes.

A76 Low-Carbon Steel Track Bolts and Nuts.

A131 Structural Steel for Ships.

A141 Structural Rivet Steel. Covers low-carbon steel for the manufacture of rivets for structural purposes.

A152 Wrought-Iron Rivets and Rivet Rounds.

A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

A164 Electrodeposited Coatings of Zinc on Steel.

A165 Electrodeposited Coatings of Cadmium on Steel.

A166 Electrodeposited Coatings of Nickel and Chromium on Steel.

A183 Heat-Treated Carbon- and Alloy-Steel Track Bolts and Carbon Steel Nuts.

A193 Alloy-Steel Bolting Materials for High Temperature Service. Covers nine grades (five ferritic steels and four austenitic steels) of alloy steel bolting material suited for service in high temperature applications. "Bolting Material" includes the bars from which the fasteners are made as well as the finished fasteners. The nine grades differ in properties, with ultimate tensile strengths ranging from 75,000 psi to 150,000 psi, and the service temperatures up to 1200° F.

A194 Carbon- and Alloy-Steel Nuts for Bolts for High-Pressure and High-Temperature Service. Covers the physical requirements of ten grades of steel nuts suited for high-pressure, high-temperature service. A194 nuts are recommended for use with A193, A320, and A354 bolts.

A195 High-Strength Structural Rivet Steel. Covers a rivet steel which is suitable, with proper driving technique, for use with high strength low alloy structural steel.

A286 Heat Treated Alloy-Steel Bars.

A307 Low-Carbon Steel Externally and Internally Threaded Standard Fasteners. Covering the physical requirements of two grades of low-carbon steel fasteners, this includes Grade A fasteners used in general applications and Grade B bolts used in flanged joints in piping systems where one or both flanges are cast iron. Grade A is similar to SAE Grade 1.

A320 Alloy-Steel Bolting Materials for Low-Temperature Service. Gives the physical requirements of nine grades of alloy-steel bolting material suited for service in low-temperature atmospheres. Selection of the grade depends on service conditions, design, mechanical properties, and low-temperature characteristics. Properties of the grades differ considerably. However, ultimate tensile strengths range up to 125,000 p.s.i. (at room temperature), and service temperatures are provided to −300° F.

A325 Quenched and Tempered Steel Bolts and Studs with Suitable Nuts and Plain Hardened Washers. Covers the physical requirements of medium carbon steel, heat-treated fasteners in sizes up to 3 in diam. A325 is equivalent to SAE Grade 5. High-strength structural bolts are manufactured to the requirements of this specification.

A354 Quenched and Tempered Alloy-Steel Bolts and Studs with Suitable Nuts. Covers the physical requirements of alloy steel, externally threaded, heat-treated parts up to 4 in. diam. Fasteners manufactured to this specification are intended primarily for applications at normal atmospheric temperatures where high strength is required. The specification, however, is also suited for limited application at elevated temperatures. Three strength levels are included (Grades BB, BC, and BD) with selection dependent on the requirements of the service application. Grade BD is the same as SAE Grade 8. Nuts for use with A354 bolts are covered in ASTM A194.

A394 Galvanized Steel Transmission Tower Bolts.

A406 High-Strength Structural Alloy Rivet Steel.

A437 Alloy-Steel Turbine-Type Bolting Material Specially Heat Treated for High-Temperature Service.

AF-Navy

Air Material Command, Wright-Patterson Air Force Base, Dayton, Ohio, or, U. S. Naval Air Station, Johnsville, Pa.

Air Force-Navy Aeronautical Standard Drawings. Dimensional standards for aircraft fasteners which were developed by the Aeronautical Standards Group.

EEI

Edison Electric Institute, 420 Lexington Ave., New York 17, N. Y.

TD-1 Steel Bolts and Nuts.

TD-3 Lag Screws.

TD-4 Eye Bolts.

TD-5 Eyenuts and Eyelets.

TD-23 Guy Clamps.

IFI

Industrial Fasteners Institute, 1517 Terminal Tower, Cleveland 13, Ohio.

Bolt, Nut, and Rivet Standards. A publication that covers nationally recognized standards for fastener products.

Hexagon Locknuts Prevailing-Torque Type Steel. Establishes the requirements for carbon and alloy steel prevailing-torque type hexagon locknuts for use in general engineering applications.

Recommended Practice for Acceptable Quality Level for Bolts, Nuts, and Similar Fasteners. Presents AQL standards. The practice recommends a sampling method for the end product only, and does not define any particular procedure of process control or inspection in the producer's plant.

Lloyd's

Lloyd's Register of Shipping, 17 Battery Place, New York, N. Y.

Rules for Steel Ships. Covering dimensional, material, and design requirements for steel rivets.

NAS

National Aircraft Standards Committee, National Standards Association, 610 Washington Loan and Trust Bldg., Washington 4, D. C.

NAS Drawings and Specifications. Contain dimensional and material standards for aircraft fasteners developed by the National Aircraft Standards Committee.

NBS

National Bureau of Standards — U. S. Dept. of Commerce. Available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Handbook H28, "Screw Thread Standards for Federal Services." The basic screw-thread standard used by all civilian and military branches of the Government, it has three parts. Part I covers Unified Screw Threads; Part II, Pipe Threads; and Part III, Miscellaneous Screw Threads. Part I conforms, except for minor details, to ASA B1.1 and, in addition, contains gage dimensions and other pertinent information and data on standard and special screw threads. Parts II and III have not yet been published, but are expected to be released shortly.

SAE

Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.

SAE Handbook. Published annually, this book covers all SAE standards, a few of which are listed.

Cap (or Acorn) Nuts.

Connecting-Rod Bolts.

Cotter Pins.

Crown (Blind, Acorn) Nuts.

High Nuts.

Lock Washers. Conforms to ASA B27.1.

Physical Requirements for Threaded Fasteners. One of the most important single specifications on fasteners, it details the physical requirements for steel bolts, cap screws, studs, and nuts used in the automotive and other industries. There are 8 grades that are recommended for bolts (Grades 0, 1, 2, 3, 5, 6, 7, and 8), four grades for cap screws (Grades 2, 3, 5, and 8), five grades for studs (Grades 1, 2, 4, 5, and 8), and three grades for nuts (Grades 2, 5, and 8). Each of these grades has different properties, with the higher numbered grades usually having superior strength characteristics than those grades with lower numbers.

Plain Washers. Conforms to ASA B27.2, except for minor editorial changes.

Round Head Bolts. Conforms to ASA B18.5 except that only certain products are included.

Screw Thread Standards. Conforms in general to ASA B1.1.

Slotted and Recessed Head Screws. Conforms to ASA B18.6.1, B18.6.2, B18.6.4, and the proposed ASA revision for machine screws.

Split and Tubular Rivets.

Spring Center Bolts.

Square and Hexagon Bolts and Nuts. Conforms in general to ASA B18.2.

Federal

Business Service Center, General Services Administration, Washington 25, D. C.

Index of Federal Specifications, Standards and Handbooks. A complete listing of all Federal documents, issued annually.

FF-W-84 Washers, Lock (Spring).

FF-S-85 Screws, Cap, Slotted and Hexagon Head.

FF-S-86 Screws, Cap, Socket Head.

FF-S-92 Screws, Machine; Slotted or Cross-Recessed.

FF-W-92 Washers, Metal, Flat (Plain).

FF-S-103 Screw: Set.

FF-S-107 Screws, Tapping, Slotted and Plain Head (Sheet Metal, Machine, and Drive).

FF-S-111 Screws, Wood, Slotted-Head.

QQ-M-151 Metals; General Specifications for Inspection of.

FF-T-305 Thumbscrews.

QQ-C-320 Chromium Plating (Electrodeposited).

QQ-Z-325 Zinc Plating (Electrodeposited).

FF-P-386 Pins, Cotter (Split).

QQ-P-416 Plating, Cadmium (Electrodeposited).

FF-R-556 Rivets, Burrs, and Caps; Copper and Brass.

FF-B-561 Bolts, Lag.

FF-B-571 Bolts; Nuts; Studs; and Tap-Rivets.

FF-B-575 Bolts, Hexagon and Square.

FF-B-584 Bolts, (Square Neck, Machine Ribbed Neck, Finned Neck, Tee Head, Key Head, Round Head).

FF-B-588 Bolts, Toggle.

FF-N-836 Nuts, Hexagon and Square.

FF-N-845 Nut, Plain, Wing.

FF-W-00100 (GSA-FSS) Washers, Tooth Lock.

FF-S-00109 (COM-NBS) Screws, Wood; Cross-Recessed Head.

MIL

Commanding Officer, Naval Aviation Supply Depot, 700 Robbins Ave., Philadelphia 11, Pa., Attn: CDS.

MIL-STD-9 Screw Thread Conventions and Methods of Specifying.

MIL-STD-105 Sampling Procedures and Tables for Inspection of Attributes. Quality control requirements for all parts purchased by the military services.

MIL-B-857 (Ships) Bolts, Nuts, and Studs.

MIL-S-933 Screws, Machine, Cap and Set; and Nuts.

MIL-S-971 (Ships) Screws, Wood.

JAN-R-1127 Rivets, Belt, Copper; and Burrs, Copper.

MIL-R-1150 Rivets, Solid (Aluminum Alloy) and Aluminum Alloy Rivet Wire and Rod.

MIL-R-1166 Rivets for Sheet Metal Work.

MIL-S-1222 Studs, Continuous Thread (Bolt-Studs); Nuts, Plain, Hexagon; and Steel Bars, Round; High Temperature Service.

MIL-R-1223 Rivets and Rivet Steel Bars. (For Hull Construction.)

MIL-R-2582 Rivets, Tubular and Cap.

MIL-R-2583 Rivets, Belt and Burrs.

MIL-B-2677 Bolts and Clips (Alloy Steel) and Nuts (Carbon Steel) Holding Down (For Ordnance Mounts).

MIL-R-2890 Rivets and Tap-Rivets. Non-Ferrous, for Hull Construction.

MIL-B-2938 Bolts, and Nuts, Deck.

MIL-N-3336 Nut, Self-Locking, Instrument Mounting.

MIL-N-3337 Nut; Sheet Spring.

MIL-B-3964 Bolts and Nuts, Track.

MIL-P-5673 Pins; Flat Head; Aircraft.

MIL-R-5674 Rivets; Aluminum and Aluminum Alloy, Aircraft.

MIL-S-6033 Screws; Self-Tapping, Steel, Aircraft.

MIL-N-6034 Nuts; Aircraft.

MIL-B-6461 (USAF) Bolts; Aircraft Engine and Propeller.

MIL-B-6812 Bolts; Aircraft.

MIL-S-7742 Screw Threads, Standard, Aeronautical.

MIL-B-7838 Bolt, Internal Wrenching 160,000 psi.

MIL-S-7839 Screws, Structural, Aircraft.

MIL-N-7873 Nut, Self-Locking, 1200° F.

MIL-B-7874 Bolt, Machine, 1200° F.

MIL-R-7885 Rivets; Blind, Aluminum Alloy.

MIL-P-12932 Packaging of Bolts and Nuts.

MIL-R-16503 (BuOrd) Rivet Rods and Rivets, Steel (for Torpedo Construction).

MIL-R-16759 (BuOrd) Rivets, Brass and Copper (for Torpedo Construction).

MIL-S-18247 Studs, Plain, Steel General-Purpose.

MIL-B-18695 (Navy) Bolts and Nuts; Plow, Pole Line, Hook and Shoulder.

MIL-N-25027 (ASG) Nut, Self-Locking, 250° F., 550° F., and 800° F.

MIL-S-18241 (AER) Screws, Self-Locking, 250° F.

MIL-S-21472 Screw, Shoulder, Socket Head, Alloy Steel.

DESIGN DATA

CHAPTER 3

Screw-Thread Forms

TECHNICAL INFORMATION STAFF
Industrial Fasteners Institute, Cleveland, Ohio

Table 1—Major Unified Thread Series

Coarse-Thread Series (UNC)
Used for bolts, screws, nuts in all general engineering applications where conditions do not require a finer pitch thread. Areas of application include cast and malleable iron, soft metals, plastics and threaded parts that require rapid assembly or disassembly.

Fine-Thread Series (UNF)
Suitable for bolts, screws, nuts, and general applications where thread engagement is limited, or where other conditions such as thin walls may necessitate the use of a fine pitch. This series is normally not recommended for use in soft metals, plastics, etc.

Extra-Fine Thread Series (UNEF)
Widely used in aircraft, missiles, and other aeronautical equipment where three requirements must be met: 1. Thin-wall material is to be threaded. 2. Thread depth of nuts and coupling flanges must be held to a minimum. 3. Maximum practicable number of threads is required within a given length of thread engagement.

4-Thread Series (4UN)
Uniform-pitch series. Basically, a continuation of the coarse-thread series in sizes over 4 in.

8-Thread Series (8UN)
Uniform-pitch series originally developed for high-pressure applications, such as bolts for high-pressure pipe flanges, cylinder-head studs, etc. Often used as a substitute for coarse-thread series in fastener diameters large than 1 in.

12-Thread Series (12UN)
Uniform-pitch series originally developed for use in boilers. It is now used for large-diameter fasteners that require medium-pitch threads. Most common application is thin nuts on shafts and sleeves in machine assemblies. Also serves as a continuation of the fine-thread series for fastener diameters larger than 1½ in.

16-Thread Series (16UN)
Uniform-pitch series. Used for large-diameter fasteners that require fine-pitch threads. Common applications include retaining nuts and threaded adjusting collars. Also serves as a continuation of the extra-fine thread series for fastener diameters larger than 2 in.

Table 2—Basic Dimensions of Unified Miniature (UNM) Screw Threads

Nominal Size* (mm)	Threads per in.	Basic Major Diameter (mm)	Basic Major Diameter (in.)	Basic Pitch Diameter (in.)	Basic Minor Diameter (in.)	Sectional Area at Minor Diameter (0.0001 sq in.)
0.30	318	0.300	0.0118	0.0098	0.0085	0.475
0.35	282	0.350	0.0138	0.0115	0.0101	0.671
0.40	254	0.400	0.0157	0.0132	0.0117	0.901
0.45	254	0.450	0.0177	0.0152	0.0136	1.262
0.50	203	0.500	0.0197	0.0165	0.0146	1.407
0.55	203	0.550	0.0217	0.0185	0.0165	1.852
0.60	169	0.600	0.0236	0.0198	0.0175	2.03
0.70	145	0.700	0.0276	0.0231	0.0204	2.76
0.80	127	0.800	0.0315	0.0264	0.0233	3.60
0.90	113	0.900	0.0354	0.0297	0.0262	4.56
1.00	102	1.000	0.0394	0.0330	0.0291	5.63
1.10	102	1.100	0.0433	0.0369	0.0331	7.41
1.20	102	1.200	0.0472	0.0409	0.0370	9.43
1.40	85	1.400	0.0551	0.0474	0.0428	12.57

*Sizes shown in bold type are preferred. It is recommended that selections be confined to these sizes where possible.

ESSENTIALLY only one screw thread form is now being used in 99 per cent of the threaded fasteners manufactured in this country. It is the Unified thread form, Fig. 1. Other screw-thread forms have been developed for fasteners but have found only limited acceptance and application.

Details of the Unified thread form are covered in *American Standard Unified Screw Threads* (ASA B1.1—1960) which lists eleven series of standard diameter-pitch combinations.

Set up by standardization committees from the United States, Canada, and the United Kingdom, the current Unified thread form is based on three previous thread forms: V, Sellers, and the American National.

Thread Series

The various thread series are classified and distinguished by the number of threads per inch for a specific fastener diameter. Data on the standard Unified coarse and fine series are tabulated in Table 2, Chapter 6.

Application characteristics of the major Unified thread series are summarized in Table 1.

These seven thread series cover the majority of screw-thread requirements encountered in design. All threads in these standard series, from No. 0 through 6 in., are now Unified and carry the symbol UN. Thus, whenever threads of these nominal sizes are specified in the United Kingdom or Canada, they will be interchangeable with threads of comparable size produced in the U.S.A.

Other screw thread standards are: Whitworth (British), British Association Standard, and International Metric Standard.

The Unified thread standard has been generally accepted throughout the U.S.A. The standard has also been accepted by the International Organization for Standardization (ISO), as a first draft proposal, to

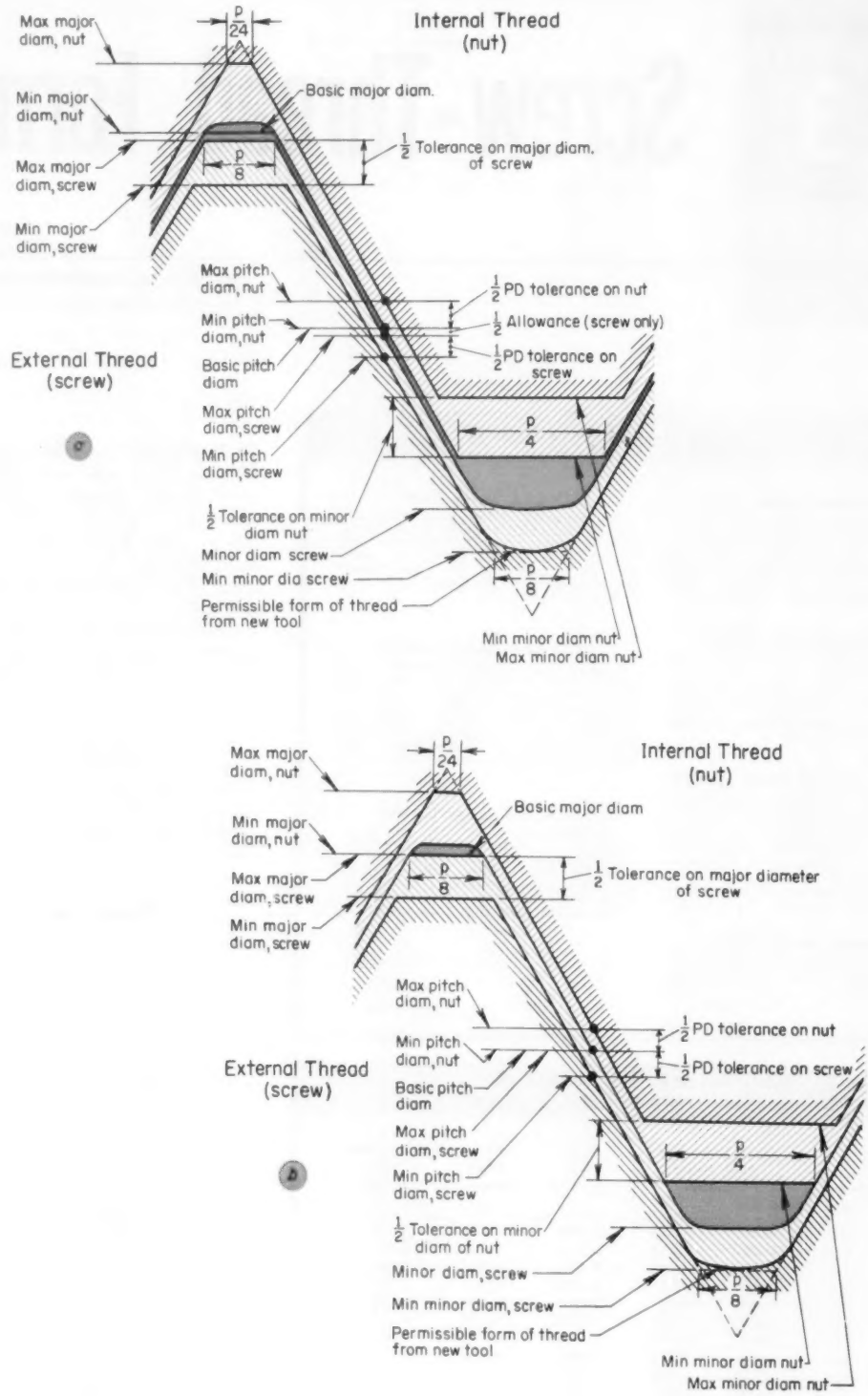


Fig. 1—Basic Unified thread form. Disposition of tolerances, allowance, and crest clearances for thread classes 1A/1B and 2A/2B is shown at *a*, for thread classes 3A/3B at *b*. Pitch *p* is reciprocal of number of threads per in.

form the basis of an international recommendation for screw threads in inch measure.

Thread Classes

Straight screw threads are classified or distinguished from each other by the amount of manufacturing tolerance and allowance, if any, permissible for externally or internally threaded components. The required assembly fit may be obtained by selecting the proper thread class for each component. Thread classes are: 1A, 1B; 2A, 2B; 3A, 3B; 5. Normally, only classes 2A/2B and 3A/3B are used in this country. These classes are unified in the sense that they are also the recognized standards in Canada and the United Kingdom.

The letter A designates tolerances and allowances applicable to externally threaded fasteners, such as studs and bolts. The letter B denotes tolerances which apply to internally threaded elements such as nuts.

Classes 1A/1B: Provide a loose fit. Used where parts must be assembled quickly and easily, even though the threads are slightly bruised or dirty.

Classes 2A/2B: Used in the majority of screws, bolts, nuts, and other commercially manufactured threaded fasteners. Maximum dimensions of class 2A are reduced from the basic size by an allowance for clearance: 30 per cent of the class 2A pitch-diameter tolerance. This allowance minimizes galling and seizure in high-temperature applications or high-cycle wrench-assembly operations. It also accommodates plated finishes or coatings. This allowance permits specification of minimum plating to a thickness of 1/6 of the allowance without the maximum plating increasing the maximum diameters beyond the basic size.

Classes 3A/3B: Designed for no allowance. Intended for use on parts where close fit and accuracy of lead and angle of thread are required. Fasteners with this class fit must be produced with highly accurate tools and carefully inspected.

Class 5: Interference thread fits. Used primarily for tap-end stud threads (See Chapter 8).

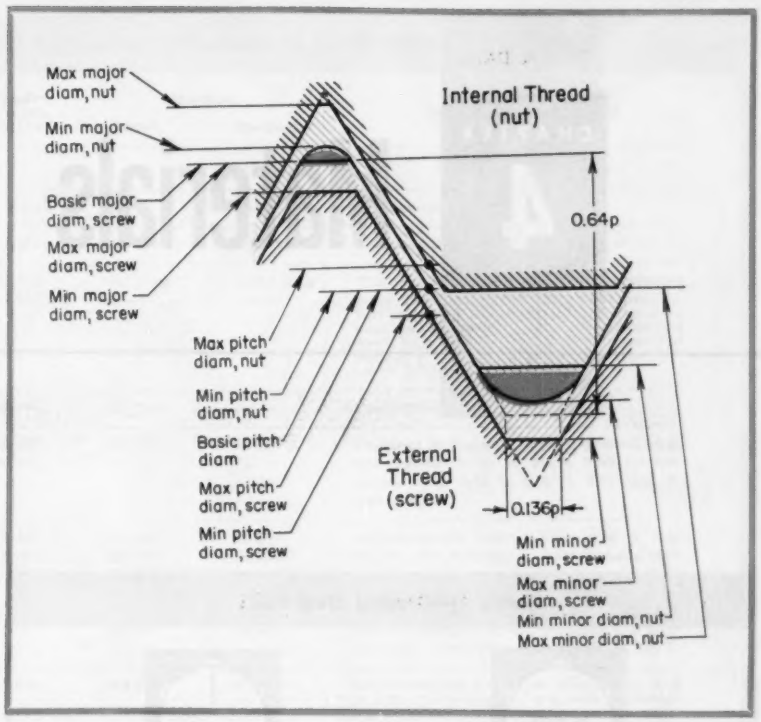


Fig. 2—Basic Unified miniature thread form. Pitch *p* is reciprocal of number of threads per in.

Miniature Screw Threads

A new thread series has been introduced in *American Standard Unified Miniature Screw Threads* (ASA B1.10-1958). This standard covers general-purpose fastening screws and similar parts in instruments, and miniature mechanisms. Screw-thread diameters range from 0.30 to 1.40 mm (0.0118 to 0.0551 in.), supplementing the Unified thread series which begin at 0.060 in. (No. 0 of the fine-thread series). Fourteen sizes and pitches of miniature screw threads are covered. The thread forms are compatible in all respects with the Unified and ISO basic thread profile. Thus, this thread series establishes interchangeability with the corresponding sizes in both the American-British-Canadian and ISO standardization programs. Fig. 2 shows the thread form and Table 2 lists important dimensions and areas.

DESIGN DATA

CHAPTER 4

Materials

TECHNICAL INFORMATION STAFF
Industrial Fasteners Institute, Cleveland, Ohio

SINCE fasteners are available in virtually any material, design choices are practically unlimited. The key to material selection for fasteners is in knowing what job the fastener has to do, then specifying a material to meet those requirements. Consider these questions:

1. Will the fastener be subjected to a corrosive condition?
2. Will the fastener be used in high temperatures?
3. Is weight important?
4. Should the material be nonmagnetic?
5. Will the fastener be subjected to high vibrations or cyclic fatigue stresses?
6. Does it need good heat or electrical conductivity?
7. What about cost?
8. Is it necessary that the fastener be used over and over again?
9. Should the life expectancy of the fastener match the life expectancy of the device fastened?
10. In what type of industry will the fastener be used?

All of these questions should be considered before selecting a fastener material. In an electric motor, for example, a fastener of a magnetic material could not be used next to the coil. A titanium fastener used with magnesium would cause galvanic corrosion. A zinc-plated fastener should not be used with equipment that will come in contact with food.

When specifying a fastener material, attempt to be a little broad-minded about exact chemical analyses, unless a special electrical or chemical property is necessary. Specifying an analysis not normally stocked adds to cost and delivery time.

In many cases it is possible for a manufacturer to meet a given set of physical specifications by cold working or heat treating one of the common materials

Table 1—Graded Steel Bolts

SAE Grade 0
Reference where no particular mechanical requirements are necessary.

SAE Grade 1 **ASTM A 307**
Low-carbon steel suited for cold and hot heading. Used for large upsets such as square-head bolts, carriage bolts, etc.

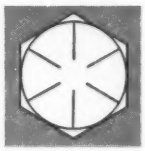
SAE Grade 2
Low-carbon steel, bright finish. Primarily intended for cold-headed products. Cold working increases strength. Widely used for cold-headed hexagon bolts. Sometimes necessary to stress relieve fasteners with large upset heads.

SAE Grade 3
Medium-carbon steel bolt. Cold-worked by heading, extrusion of the blank, and roll threading. May be aged at 700 F to meet required mechanical properties. Limited to fastener products ¾ in. diam and 6 in. in length. Higher fatigue strength than Grade 2. Limited in ductility and ultimate strength when compared to SAE Grade 5, same as Grade 5 without heat treating. Grade 3 offers no special fatigue advantages in usual joint design.

SAE Grade 5 **ASTM A 325**
A quenched and tempered medium-carbon steel bolt. Recommended where high preloading of the bolt is practical. This grade is considered the most economical on a highest-clamping-force per dollar-of-bolt-cost basis.

SAE Grade 6
A special medium-carbon steel bolt, oil-quenched and tempered. Has a higher manganese content. Because of oil quenching and limited size range, it is possible to reach higher hardenability and slightly higher strengths. Useful where higher properties than Grade 5 are required, without expense of using an alloy steel.

SAE Grade 7
A quenched and tempered medium-carbon alloy steel. Threads are cold rolled after heat treatment for improved fatigue strength.



SAE Grade 8 **ASTM A 354, Grade BD**
Quenched and tempered medium-carbon alloy steel which has a higher strength than Grade 7 material.

Table 2—Physical and Mechanical Requirements for Threaded Fasteners

Grade	Bolt Size Diam (in.)	Proof Load (psi)	Tensile Strength, Min (psi)	Hardness		Material—Heat Treatment
				Brinell	Rockwell	
Bolts and Capscrews						
0	All sizes	——	——	——	——	No requirements.
1	All sizes	——	55,000	207 max	95 B max	Commercial steel.
2	Up to ½ incl	55,000	69,000	241 max	100 B max	This is intended to be a cold-headed product made from low-carbon steel; 0.28 max C, 0.04 max P, 0.05 max S. Lengths over 6 in. may be hot-headed from medium-carbon steel; 0.55 max C. Deviation from specified chemistry may be made by agreement between producer and consumer.
	Over ½ to ¾ incl	52,000	64,000	——	——	
	Over ¾ to 1½ incl	28,000	55,000	207 max	——	Commercial steel.
3	Up to ½ incl	85,000	110,000	207-269	95-104 B	Produced by the cold heading process, up to and including 6 in. in length from medium carbon steel; 0.28 to 0.55 C, 0.04 max P, 0.05 max S.
	Over ½ to ⅝ incl	80,000	100,000	——	——	
5	Up to ¾ incl	85,000	120,000	241-302	23-32 C	Medium-carbon steel; 0.28 to 0.55 C, 0.04 max P, and 0.05 max S. Quenched and tempered at a minimum temperature of 800 F.
	Over ¾ to 1 incl	78,000	115,000	235-302	22-32 C	
	Over 1 to 1½ incl	74,000	105,000	223-285	19-30 C	
6	Up to ⅝ incl	110,000	140,000	285-331	30-36 C	Medium-carbon steel; 0.28 to 0.55 C, 0.04 max P, 0.05 max S. Oil quenched and tempered at a minimum temperature of 800 F.
	Over ⅝ to ¾ incl	105,000	133,000	269-331	28-36 C	
7	Up to 1½ incl	105,000	133,000	269-321	28-34 C	Medium-carbon fine-grain alloy steel; 0.28 to 0.55 C, 0.04 max P, 0.05 max S, providing sufficient hardenability to have a minimum oil-quenched hardness of 47 Rc at the center of the threaded section, one diameter from the end of the bolt. Oil-quenched and tempered at a minimum temperature of 800 F. Roll threaded after heat treatment.
8	Up to 1½ incl	120,000	150,000	302-352	32-38 C	Medium-carbon fine-grain alloy steel; 0.28 to 0.55 C, 0.04 max P, 0.05 max S, providing sufficient hardenability to have a minimum oil-quenched hardness of 47 Rc at the center of the threaded section one diameter from the end of the bolt. Oil quenched and tempered at a minimum temperature of 800 F.
Studs						
1	Up to 1½ incl	——	55,000	241 max	100 B max	Commercial steel.
2	Up to ½ incl	55,000	69,000	241 max	100 B max	Any SAE steel, 0.55 max C, 0.12 max P, 0.33 max S.
	Over ½ to ¾ incl	52,000	64,000	——	——	
	Over ¾ to 1½ incl	28,000	55,000	——	——	
4	Up to 2 incl	——	115,000	——	22-32 C	Medium-carbon, cold-drawn SAE steel, 0.55 max C, 0.04 max P, 0.33 max S.
		——	100,000*	——	——	
5	Up to ¾ incl	85,000	120,000	241-302	23-32 C	Any SAE steel, 0.28 to 0.55 C, 0.04 max P, 0.13 max S. Quenched and tempered at a minimum temperature of 800 F.
	Over ¾ to 1 incl	78,000	115,000	235-302	22-32 C	
	Over 1 to 1½ incl	74,000	105,000	223-285	19-30 C	
8	Up to 1½ incl	120,000	150,000	302-352	32-38 C	Any SAE fine-grain alloy steel, 0.28 to 0.55 C, 0.04 max P, 0.05 max S, providing sufficient hardenability to have a minimum oil-quenched hardness of 47 Rc at the center of the threaded section, one diameter from the end of the bolt. Oil quenched and tempered at a minimum temperature of 800 F.

*Min yield strength (psi).

on hand. Requirements often call for a high-strength material because of weight or space limitations. But even here, specifying the physicals, instead of the composition, will force the manufacturer to use a high-alloy steel.

The problems of corrosion can be met by using: 1. Protective coatings and finishes. 2. Nonferrous, corrosion-resistant alloys. 3. Nonmetallic fasteners.

Fastener finishes and protective coatings are discussed in Chapter 5. Briefly, a protective coating should only be used where the fastener will be subject to mildly corrosive conditions. For extremely corrosive conditions, a fastener made of metal that has inherent corrosion resistance should be specified.

Steel

The greatest number of fasteners used are made from standard analyses of steel. Standard specifications for ferrous fasteners cover a broad range of mechanical properties. These specifications include a marking system, Table 1, which identifies bolt heads by grade. SAE Grades

2, 5, and 8 are the most often specified.

SAE and ASTM Grade specifications include proof load, tensile strength and hardness of threaded fasteners, Table 2. The most commonly used steels are:

1. SAE 1010. Machine screws, carriage bolts, similar products without critical strength requirements.
2. SAE 1018, 1020, 1021. Bright cap screws, special items.
3. SAE 1038. High-strength bolts and cap screws.
4. SAE 1041, 1045, 1330 and 1340. For special requirements.
5. SAE 1100 series (resulfurized). Usually used for nuts with some also being made from SAE 1016, 1038 and a hot-formed nut from SAE 1045.

Aluminum

Aluminum has an entire family of alloys that are the least costly, by volume, of all the metals. It is easily alloyed with other metals and is widely used as a fastener material. There are two groups of aluminum fasteners, hardenable and nonhardenable.

Aluminum weighs about one-third as much as mild steel, and can equal or even exceed the tensile strength, Table 3, of mild steel. It will polish to a high luster. It possesses high heat and electrical conductivity and it is nonmagnetic. Aluminum can be hardened by alloying, and it has a remarkable immunity to corrosion.

Aluminum is ideal for applications where high strength-to-weight ratio, durability, corrosion resistance, and good appearance are desired. Typical fastener alloys are:

1. 2024-T4. Cold-formed bolts, screws, rivets, machine-screw nuts.
2. 2011-T3. Milled-from-bar nuts, screws, bolts.
3. 1100. Cold-formed rivets.

Brass

Brass usually is composed of copper, zinc and a hardening agent such as tin. Relatively inexpensive, the brasses have many uses in fastener design. They are easily worked into any shape and possess adequate strength, Table 3. The brasses cannot be hardened or tempered by heat treatment. Tensile strength or hardness is improved only by cold working. In many cases, cold-worked fasteners must be stress relieved to eliminate embrittlement and improve corrosion resistance.

Cold-drawn brass has a greater tensile strength than mild carbon steel, yet it has a higher resistance to corrosion than steel. It will take a high, lustrous finish and is nonmagnetic.

Table 3—Nonferrous Fastener Materials

Material	Tensile Strength (psi)	Yield Strength, 0.5% Elongation (psi)	Rockwell Hardness	Electrical Conductivity*
Aluminum				
2024-T4	55,000 min 60,000 avg	50,000	B 54-63	30
2011-T3	55,000 avg 13,000 min	48,000	B 50-60	40
1100	16,000 avg	5,000	F 20-25	57
Brasses				
Yellow brass	60,000 min 72,000 avg	43,000	B 57-65	27
Free-cutting brass	50,000 min 55,000 avg	25,000	B 53-59	26
Commercial bronze	45,000 min 50,000 avg	40,000	B 40-50	44
Naval bronze, composition A	55,000 min 65,000 avg	33,000	B 45-50	26
Naval bronze, composition B	50,000 min 60,000 avg	31,000	B 45-50	26
Copper	35,000 to 45,000	10,000 to 37,000	F 40-80	101
Silicon Bronze				
High-silicon, Type A	70,000 min 80,000 avg	38,000	B 74-80	7
Low-silicon, Type B	70,000 min 76,000 avg	35,000	B 67-75	12
Silicon-Aluminum	80,000 min 85,000 avg	42,000	B 76-82	7
Nickel and High Nickel				
Monel	82,000 min 97,000 avg	60,000	B 90	..
Nickel	68,000 to 82,000	20,000 to 65,000	B 75-86	..
Inconel	80,000 to 120,000	25,000 to 70,000	B 72 to C 24	..
Stainless Steel (AISI)				
Type 302	90,000 to 124,000	35,000 to 116,000	B 89 to C 25	..
Type 303	90,000 to 124,000	35,000 to 116,000	B 89 to C 25	..
Type 304	85,000 to 112,000	30,000 to 92,000	B 87 to B 98	..
Type 305	80,000 to 110,000	30,000 to 95,000	B 84 to B 97	..
Type 309	100,000 to 120,000	40,000 to 100,000	B 94 to C 23	..
Type 310	100,000 to 120,000	40,000 to 100,000	B 94 to C 23	..
Type 316	90,000 to 115,000	30,000 to 95,000	B 89 to B 99	..
Type 317	90,000 to 115,000	30,000 to 95,000	B 89 to B 99	..
Type 321	90,000 to 112,000	30,000 to 92,000	B 89 to B 98	..
Type 347	90,000 to 112,000	35,000 to 95,000	B 89 to B 98	..
Type 410	75,000 to 190,000	40,000 to 140,000	B 81 to C 42	..
Type 416	75,000 to 190,000	40,000 to 140,000	B 81 to C 42	..
Type 430	70,000 to 90,000	40,000 to 183,000	B 77 to B 90	..

*Approximately the percentage of conductivity of international annealed copper standard at 68 F. (Actual conductivity of this copper standard is 101.)

Typical fastener alloys are:

1. **Yellow brass.** Cold-headed bolts, screws, rivets.
2. **Free-cutting brass.** Milled-from-bar nuts, bolts, set screws.
3. **Commercial bronze.** Cold-headed bolts, screws, rivets, milled-from-bar nuts.
4. **Naval bronze, composition A.** Milled-from-bar bolts and nuts. Hot-forged bolts.
5. **Naval bronze, composition B.** Cold-formed bolts and nuts.

Copper

Electrolytic, tough-pitch copper is one of the most malleable of all the metals. It can be severely formed, and has high resistance to corrosion by the elements, and stress corrosion. Electrical conductivity is higher than any other nonprecious metal.

Copper is usually alloyed with silicon, along with manganese or aluminum, to add strength. Lead can be added to give free-machining qualities. These copper alloys are called silicon bronze. Here are typical applications:

1. **High-silicon bronze, type A.** Hot-forged bolts, nuts; milled-from-bar bolts, nuts, set screws.
2. **Low-silicon bronze, type B.** Cold-formed bolts, nuts, rivets, screws.
3. **Silicon-aluminum bronze.** Hot-forged products requiring special properties.
4. **Cupro-nickel.** A copper-nickel used for high strength. Excellent resistance to corrosion from sea water. Cold works easily.

Nickel

Nickel fasteners may be made from the commercially pure metal, which is 99.4 per cent pure, or Monel or Inconel. Monel and Inconel are high-nickel alloys that possess strength, hardness and corrosion resistance.

Nickel alloys find use in chemical and food processing. They are useful where toughness, immunity to discoloration and corrosion, and strength at high temperatures are desired. Here are typical nickel fastener alloys:

1. **Monel.** All bolts, nuts, screws, rivets, milled-from-bar, cold or hot worked. This is the common nickel alloy for fasteners combining relative economy with adaptability to cold heading and roll threading.
2. **Nickel.** Costs more than Monel and has less strength. Its qualities are ideal for applications involving contamination, and the retention of strength at both high and subzero temperatures.
3. **Inconel.** Excellent for fasteners that must retain high strength and resistance to oxidation at temperatures ranging up to 1600 F.

Stainless Steels

Stainless-steel fasteners can be used for problems of corrosion, temperature and strength. The high tensile strength, corrosion-resistant qualities and ability to attain a mirror-like finish make stainless one of the most versatile of all metals.

Broadly defined, stainless steels are iron alloys containing from 12 to 30 per cent chromium and from 0 to 20 per cent nickel. The corrosion resistance of the stainless-steel fastener is the result of passivity. When oxygen comes into contact with the surface it forms an invisible film which protects the underlying metal from rusting and corrosion under severe conditions.

There are three basic stainless steel groups:

1. **Martensitic.** Straight chromium hardenable. These steels contain from 12 to 20 per cent chromium, are magnetic and hardenable. Common fastener alloys are Type 410, 416, and 431.
2. **Ferritic.** Straight chromium, nonhardenable. Also chromium stainless-steel alloys. Are magnetic and not hardenable by heat. They can be cold worked with reasonably good results. Used for economic reasons, and where corrosion-resistance requirements are not too severe. Best fastener alloy types are 430 and 430 F.
3. **Austenitic.** Chrome-nickel, nonhardenable. This group is generally made up of the 18-8, or the 300 series stainless steels. They contain upward of 8 per cent nickel, are nonmagnetic and offer the greatest degree of corrosion resistance.

Nonmetallic Materials

Nonmetallic fasteners have certain advantages over metallic fasteners. Nonmetallic fasteners usually do not need special finishes or coatings for corrosion protection. Plastic fasteners are easily colored. The fastener, if desired, can be colored to match or harmonize with other components or products.

Plastics are very good thermal and electrical insulators. Nonmetallic fasteners can be used to insulate one unit from another. One example would be the insulation of an electronic chassis from the cabinet. Plastics are also light in weight. The weight ratio of steel to nylon is 6 to 1.

Several different nylon and plastic compositions are currently being used for fasteners:

1. **Nylon.** One of the most common is Du Pont Zytel 101. It is used for stock fastener shapes. It is a polyamide plastic of the nylon 6/6 type. It has good insulating properties, plus resistance to heat, shock, vibration, and chemical solvents. In addition it possesses lightness, elasticity, and superior torque strength.
2. **Teflon and PVC.** Used for special fasteners only.
3. **Polystyrene.** Low cost. Has less strength than nylon. Can be used for temperature applications up to 160 F.
4. **Polyethylene.** Low cost; medium strength. It is a good insulator and has "rubber-like" characteristics. Can be used for temperature applications up to 190 F.
5. **Vinyl.** Used for many special fastener applications. Has good elasticity and good resistance to chemical corrosion.
6. **Other** nonmetallic fastener materials are Delrin, Kel-F, Lexan, and Nylatron GS.

Fastener applications where nonmetallic materials are not recommended include temperatures exceeding 350 F, shear or high stress requirements, or where cost per piece is critical. Tooling costs of a production mold for a special-design fastener are expensive, and only justified during a high production run.

DESIGN DATA

CHAPTER 5

Finishes & Coatings

TECHNICAL INFORMATION STAFF
Industrial Fasteners Institute, Cleveland, Ohio

COATINGS or special finishes on a fastener have two main purposes: 1. To improve appearance. 2. To increase corrosion resistance.

On applications such as appliances, indoor decorative trim, and other mild corrosion situations, the primary consideration is appearance. The decorative finishes are used to match mating surfaces or brighten the part for pleasing appearance and sales appeal. Many of the decorative finishes offer little corrosion protection, so they are seldom used for outdoor or corrosive situations.

A protective coating, Table 1, must be used for fasteners subjected to severe corrosion conditions, such as marine hardware. Often, a protective coating is used on ferrous fasteners, instead of using corrosion-resistant material, because of lower cost. Use protective coatings only where the fastener will be subject to mildly corrosive conditions. For extremely corrosive conditions, specify a fastener made of material that has inherent corrosion resistance.

Base decisions on finishes and coatings on these factors:

1. Whether coating or finish is for decoration or protection, or both.
2. Type of material, or plated surface, of the mating parts.
3. Required color match, if any.
4. Physical aspects required that may limit the type of fastener material used.
5. Type of corrosion expected during service.
6. Availability of the finishing process.
7. Cost.

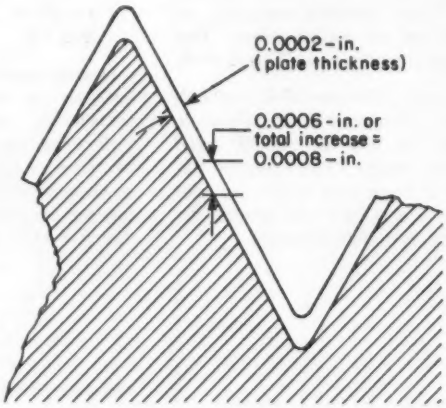


Fig. 1—Plated coating on an external screw thread showing build-up on pitch diameter. From Walton R. Yerger, "Fastener Finishes," Aug. 23, 1956.

Plating

Zinc, cadmium, tin, nickel, and chromium are the most common electrodeposited metallic coatings for fasteners. Zinc and cadmium offer about equal protection against ordinary atmospheric corrosion, but zinc is preferred for outdoor use. Cadmium is preferred indoors because of its cleaner appearance, but is more expensive than zinc. A protective film of corrosion products forms on zinc and cadmium surfaces; however, the film on cadmium will wash off in rain.

Tin plating does not protect ferrous products from atmospheric corrosion very well. It is good for parts that come in contact with food. Nickel coatings resist certain chemicals and remain attractive for a long time. Chromium is a good protector, but it requires a base plate of copper or nickel, or both, on ferrous materials.

Electroplating a threaded fastener can change the thread angle, Fig. 1. On external threads, the plate will be thickest at the top of the thread. On internal threads, the plate will be thickest at the root diameter and taper down to the minor diameter of the thread. This will alter the thread angle slightly, but in the reverse direction to the plated external thread. Class 2A/2B Unified threads have an allowance on the external thread that will accommodate electroplating. Usually Class 2A/2B threads require no additional processing of the threads. Class 3A/3B Unified threads have no allowance on the external thread; consequently, either the nut must be tapped oversize or the bolt threads undercut to assure fit of plated parts.

Table 1—Fastener Finishes and Coatings

Coating or Finish for Fasteners	Used On	Corrosion Resistance	Characteristics
Anodizing	Aluminum	Excellent	Acid electrolytic treatment for aluminum, frosty-etched appearance. Hard oxide surface gives excellent protection.
Black oxide, blued	Steel	Indoor satisfactory, outdoor poor. Protection afforded mainly by wax or oil coatings	Hot-alkali chemical process, black, can be waxed or oiled. Produces a rust-inhibited surface.
Black chromate	Zinc-plated or cadmium-plated steel	Added corrosion protection on cadmium and zinc-plated surfaces	Black, semilustrous. Chemical dip. Used for decorative outdoor purposes. Can be lacquered.
Bluing	Steel	Indoor satisfactory, outdoor poor. Protection afforded mainly by wax or oil coatings	Coloring process by heat tinting. Decorative use. Blue to black, can be waxed or oiled.
Brass plate, lacquered	Steel, usually	Fair	Brass electroplated finish which is then lacquered. Recommended only for indoor decorative use.
Bronze plate, lacquered	Steel, usually	Fair	Has color similar to 80% copper, 20% zinc alloy. Electroplated, lacquered finish. Only recommended for indoor decorative use.
Cadmium plate	Most metals	Very good	Bright silver-gray, dull gray or black electroplated finish. Used for both decoration and corrosion protection.
Clear chromate finish	Cadmium and zinc-plated parts	Very good to excellent	Clear bright or iridescent chemical conversion coating applied to zinc or cadmium-plated surfaces for added corrosion protection, coloring, and paint bonding. The colored coatings usually have greater corrosion resistance than the clear.
Dichromate	Cadmium and zinc-plated parts	Very good to excellent	Yellow, brown, green, or iridescent colored coating same as clear chromate.
Olive drab, gold, or bronze chromate	Cadmium and zinc-plated parts	Very good to excellent	Green, gold, or bronze tones same as clear chromate.
Chromium plate	Most metals	Good (improves with increased copper and nickel undercoats)	Bright blue-white, lustrous electroplated finish. Has relatively hard surface. Used for decorative purposes.
Copper plate	Most metals	Fair	Electroplated finish. Used for nickel and chromium-plate undercoat. Can be blackened and relieved to obtain Antique, Statuary, and Venetian finishes.
Copper, brass, bronze misc. finishes	Most metals	Indoor, very good	Decorative finishes. Applied to copper, brass, bronze-plated parts to match colors. Color and tones vary from black to almost the original color. Finish names are: Antique, Black Oxide, Statuary, Old English, Venetian, Copper Oxidized.
Lacquering, clear or color-matched	All metals	Improves corrosion resistance. Some types designed for humid or other severe applications	Used for decorative finishes. Clear or colored to match mating color or luster.
Lead-tin	Steel, usually	Fair to good	Silver-gray, dull coating. Gives good lubrication to tapping screws. Applied by hot-dip method.
Bright nickel	Most metals	Indoor excellent. Outdoor good if thickness is at least 0.0005 in.	Electroplated silver finish. Used for appliances, hardware, etc.
Dull nickel	Most metals	Same as bright nickel	Whitish cast. Can be obtained by mechanical surface finishing or using a special plating bath.
Passivating	Stainless steel	Excellent	Chemical treatment. Removes iron particles and produces a passive surface.
Phosphate Bearing Surfaces, Army 57-0-2, Type II, Class A	Steel	Good	Antichafing properties used on sliding or bearing surfaces. Black manganese-iron phosphate coating with nondrying petroleum oils containing corrosion inhibitors.
Phosphate Rust Preventive, Army 57-0-2, Type II, Class B	Steel	Fair to good	Chemical process that rustproofs steel. Plain grayish surface. Rust-preventive oils can be applied over it. Can be dyed black. The rust-preventive oils increase corrosion resistance.
Phosphate Paint-base Preparations, Army 57-0-2, Type II Class C	Steel, aluminum, zinc plate	Good, after paint or lacquer applications	Plain gray color. Chemical process for preparing steel, aluminum, and zinc-plated parts for painting or lacquering. Will increase bond between metal and coating.
Colored phosphate coatings	Steel	Superior to regular phosphated and oiled surfaces	Chemically produced color coating will increase corrosion resistance. Available in green, red, purple, blue, black, etc.
Rust preventatives	All metals	Varies with function of oil	Vary in color, and film thickness. Usually applied to phosphate and black oxide finishes. Used to protect parts in transit or prolonged storage.
Silver plate	All metals	Excellent	Decorative, expensive. Excellent electrical conductor.
Electroplated tin	All metals	Excellent	Silver-gray color. Excellent corrosion protection for parts in contact with food.
Hot-dip tin	All metals	Excellent	Silver-gray color. Same as electroplated, but thickness is harder to control, especially on fine-thread parts.
Electroplated zinc	All metals	Very good	Bright-blue-white gray coating. For corrosion protection of steel parts.
Electrogalvanized zinc	All metals	Very good	Use where bright appearance is not wanted. Dull grayish color.
Hot-dip zinc	All metals	Very good	For maximum corrosion protection. Dull grayish color Use where coating thickness is not important. Corrosion resistance is directly proportional to the coating thickness.

FASTENER CORROSION GUIDE

	BRASS AND NAVAL BRONZE	SILICON BRONZE	MONEL METAL	STAINLESS TYPES 410, 416, 430	STAINLESS TYPES 302, 303, 304, 305	STAINLESS 316	COPPER	ALUMINUM
Acetate solvents, crude								
Acetate solvents, pure								
Acetate acid, crude	1			2				
Acetic acid, pure	1			2				
Acetic acid vapors								
Acetic anhydride								
Acetone								
Acetylene	3							
Alcohols								
Aluminum sulfate	1							
Alums	1							
Ammonia gas[4]	56	6	6				6	
Ammonium chloride	1							
Ammonium hydroxide								
Ammonium nitrate								
Ammonium phosphate								
Ammonium phosphate, neutral								
Ammonium phosphate, acid	1							
Ammonium sulfate	1							35
Asphalt								
Beer				7				
Beet-sugar liquors								
Benzene or benzol[8]								
Benzine [8]								
Borax								
Boric acid	1							
Butane, butylene[9]	34	34		10	10	10	34	
Calcium bisulfite								
Calcium hypochlorite								
Cane-sugar liquors								
Carbon dioxide, dry								
Carbon dioxide, wet	11	11	11	11			11	
Carbon disulfide								
Carbon tetrachloride [12]								
Chlorine, dry								
Chlorine, wet								
Chromic acid								
Citric acid	1							
Coke-oven gas								
Copper sulfate								
Core oils								
Cottonseed oil								

	BRASS AND NAVAL BRONZE	SILICON BRONZE	MONEL METAL	STAINLESS TYPES 410, 416, 430	STAINLESS TYPES 302, 303, 304, 305	STAINLESS 316	COPPER	ALUMINUM
Creosote								
Ethers								
Ethylene glycol								
Ferric chloride								
Ferric sulfate								
Formaldehyde								
Formic acid	1			2				
Freon								
Furfural								
Gasoline, sour								
Gasoline, refined								
Gelatine	13	13		13			13	
Glucose								
Glue								
Glycerine or glycerol								
Hydrochloric acid		14	14				14	
Hydrocyanic acid								
Hydrofluoric acid								
Hydrogen fluoride								
Hydrogen [9]								
Hydrogen peroxide								
Hydrogen sulfide, dry	6	6	6				6	
Hydrogen sulfide, wet				15				
Lacquers and lacquer solv.								
Lime-sulfur								
Magnesium chloride								
Magnesium hydroxide								
Magnesium sulfate								
Mercuric chloride						16		
Mercury								
Milk								
Molasses								
Natural gas								
Nickel chloride [17]								
Nickel sulfate [17]								
Nitric acid				18				
Oleic acid	19	24		20	20		24	
Oxalic acid	1							
Oxygen [9]								
Palmitic acid	19	24		20	20		24	
Petroleum oils, sour								
Petroleum oils, ref.								

	BRASS AND NAVAL BRONZE	SILICON BRONZE	MONEL METAL	STAINLESS TYPES 410, 416, 430	STAINLESS TYPES 302, 303, 304, 305	STAINLESS 316	COPPER	ALUMINUM
Phosphoric acid, 25%		21	22		23		21	
Phosphoric acid, 25-50%		21	22				21	
Phosphoric acid, 50-85%		21	22				21	
Picric acid								
Potassium chloride								
Potassium hydroxide								
Potassium sulfate								
Propane[9]				10	10	10		
Rosin, dark								
Rosin, light								
Shellac								
Soda ash (sodium carbonate)								
Sodium bicarbonate								
Sodium bisulfate	1							
Sodium chloride								
Sodium cyanide								
Sodium hydroxide								
Sodium hypochlorite								
Sodium metaphosphate								
Sodium nitrate								
Sodium perborate								
Sodium peroxide								
Sodium phosphate, alkaline								
Sodium phosphate, neutral								
Sodium phosphate, acid	1							
Sodium silicate								
Sodium sulfate								
Sodium sulfide								
Sodium thiosulfate (hypo)								
Sludge acid								
Stearic acid	19	24		20	20		24	
Sulfate liquors								
Sulfur								
Sulfur chloride								
Sulfur dioxide, dry[9]								
Sulfur dioxide, wet								
Sulfuric acid, 10%		25	25			25		
Sulfuric acid, 10-75%								
Sulfuric acid, 75-95%		26	26	27	27	27	26	
Sulfuric acid, 95%								
Sulfurous acid								
Tar								

	BRASS AND NAVAL BRONZE	SILICON BRONZE	MONEL METAL	STAINLESS TYPES 410, 416, 430	STAINLESS TYPES 302, 303, 304, 305	STAINLESS 316	COPPER	ALUMINUM
Tartaric acid	1							
Toluene or toluol[8]								
Trichloroethylene[12]								
Turpentine	28			28				
Varnish[29]								
Vegetable oils[29]								
Vinegar[25]								
Water, acid mine		30	30	31	31	31	30	
Water, fresh	32							
Water, salt	32			33	33	33		
Whiskey								
Wines								
Xylene or Xylol[8]								
Zinc chloride								
Zinc sulfate								

KEY: - EXCELLENT - FAIR - GOOD - NOT GOOD

FOOTNOTES:

1. Subject to dezincification and/or stress corrosion; especially at elevated temperatures and with concentrated solutions.
2. May be useful with cold dilute acid.
3. Alloys containing up to 60% copper acceptable; high-copper alloys not acceptable.
4. Temperature assumed to be below that at which gas cracks and liberates nascent nitrogen.
5. Subject to stress corrosion with low concentrations.
6. Apparently resistant to dry gas at ordinary temperatures; attacked rapidly by moist gas and by hot gas.
7. Not recommended for use with beverage grade.
8. Chemicals used for treating in manufacture assumed to be absent.
9. Temperature assumed to be no higher than that normally encountered in compression, storage, and distribution.
10. Useful at elevated temperatures.
11. Not recommended for use with carbonated beverages.
12. Water assumed to be absent.
13. Not recommended for use with edible grades.
14. Only with dilute or unaerated solutions.
15. Subject to stress corrosion by moist gas; and to severe general corrosion by saturated aqueous solution.
16. Subject to stress corrosion.
17. None of these materials recommended for use with nickel plating solutions.
18. Higher chromium alloys (over 18%) preferred.
19. Not recommended for temperature over 100 C (242 F).
20. Alloys with less than 18% Cr not recommended for temperatures over 100 C (212 F). Others not recommended for temperatures over 200 C (390 F).
21. Up to 60 C (140 F).
22. Up to 90 C (200 F).
23. At room temperature.
24. Not recommended for temperatures over 200 C (390 F).
25. Nonferrous alloys preferred with unaerated and at temperatures above normal. Stainless steel best when aerated and at normal to moderate temperatures.
26. With cold acid only.
27. In the absence of exposure to moist air.
28. Crude product may contain acids which corrode these materials.
29. Some of these ratings may not apply when handling light-colored products at elevated temperatures (200 C) (390 F).
30. Good with water containing no oxidizing salts; fair with water containing oxidizing salts.
31. Excellent with water containing oxidizing salts; not good with water containing no oxidizing salts.
32. Subject to dezincification with hot and/or aerated waters.
33. Subject to pitting attack.
34. Copper may act as a catalyst for undesirable reactions.
35. Free sulfuric acid absent.

Data, courtesy H. M. Harper Co.

GALVANIC SERIES

CORRODED END—ANODE
(least noble)

Magnesium
Magnesium alloys
Zinc
Aluminum 2002S
Cadmium
Aluminum 2021S-T4
Steel or iron
Cast iron
Chromium-iron (active)
Ni-Resist
Type 304 stainless (active)
Type 316 stainless (active)
Lead-tin solders
Lead
Tin
Nickel (active)
Inconel (active)
Brasses
Copper
Bronzes
Copper-nickel alloys
Monel
Silver solder
Nickel (passive)
Inconel (passive)
Chromium-iron (passive)
Type 304 stainless (passive)
Type 316 stainless (passive)
Silver
Graphite
Gold
Platinum

PROTECTED END—CATHODE
(most noble)

Chromate Treatment: Chromate treatment after plating will considerably increase the corrosion resistance of a fastener coating. The films produced are iridescent and bronze-like in appearance. Dyes can be added to some films to produce black or olive-drab colors. Bleached chromate films are also available. They are very bright and bluish in appearance, similar to a bright chromium plate.

For the additional protection they provide the fastener, the cost of after-coatings is nominal. They are particularly useful for fasteners exposed to repeated condensation and drying up of moisture. Chromate will effectively prevent rusting between the mated parts of a bolt and nut.

Do not specify chromate films on fasteners continuously subjected to rainfall or running water. Water leaches out the soluble chromates upon which the films depend for their protective value.

Hot Dip Coatings

Hot-dip coatings are relatively low-cost processes for providing a protective coating on inexpensive high-strength ferrous fasteners. Two hot-dip coatings are commonly used for fasteners: Hot-dip aluminum coatings (aluminized) and hot-dip zinc coatings (galvanized).

Only fasteners with Class 2A Unified threads are recommended for use with hot-dip coatings, but the allowance on the external thread is not sufficient for a good fit of the nut and bolt. There are two choices: Overtap the nut, or undercut the bolt. Recommended practice is to use a standard 2A blank untapped nut and tap it 1/64 in. oversize. Then use the oversize nut with a standard bolt out of stock. This method is the least expensive. To undercut the bolt would call for a special fastener, and the cost would rise accordingly.

Hot-Dip Aluminum: Used on ferrous fasteners for corrosion resistance and the heat reflectivity of aluminum. Corrosion resistance is good. In some applications hot-dip aluminum is superior to galvanized coatings, but it is more expensive.

Hot-Dip Zinc: This coating combines the qualities of high corrosion protection and low cost, and is widely used for ferrous fasteners for outdoor applications. After cleaning, the fasteners are dipped in a molten zinc bath. The coating that results usually consists of an outer layer of relatively pure zinc and lower layers of iron-zinc compounds.

The zinc coating is popular because: 1. It has a slower corrosion rate than unprotected ferrous fasteners. 2. Zinc corrosion products are white and nonstaining. 3. Zinc coatings offer electrolytic protection to the ferrous part.

Amount of protection depends on the coating thickness. The life of the zinc coating will also vary depending on the atmosphere it is subjected to. Galvanized

coating life may be 5 to 10 times greater in a rural atmosphere than in an industrial atmosphere containing sulfur and acid gases.

Corrosion

Intelligent selection of protective coatings can not be done without considering the different types of corrosion which can affect a fastener. Six major types of corrosion common with fasteners are:

1. **Uniform Corrosion:** Called rust in iron or steel, this is slow oxidation of the parent metal. It is eliminated by the use of protective paints or greases, plating, or the use of a corrosion-resistant fastener material.

2. **Galvanic Corrosion:** Two unlike metals which share an electrolyte will experience galvanic corrosion. Any liquid which will conduct an electrical current can be an electrolyte; even certain gas concentrations in air can act as electrolytes. The current set up by the two dissimilar metals appears as an ion transfer from the anode to the cathode. The metallic ion is deposited on the cathode. The anode material is destroyed, while the cathode material remains relatively unattacked.

The rate of this battery-like action is proportional to the electrical potential between the two metals. A strong electrolyte (low resistance to current flow) will increase the corrosion rate. Corrosion rate also increases as the ratio of the cathode area to the anode area increases; therefore, it is important to keep the cathodic material small and the anodic area large. For example, using a brass nut and bolt on a steel casting would minimize the galvanic effect because of the low cathode to anode ratio.

The galvanic series is a list of metals arranged in the order of their tendency to be cathodic or anodic. The farther two metals are apart in this series, the higher is the electrical potential between them. Some metals are grouped together. These are relatively safe to use with one another.

3. **Pitting:** The phenomenon which causes a metal to pit in a corrosive atmosphere instead of uniformly deteriorating is a result of an action similar to galvanic corrosion, except that the cathode and anode are the same piece of metal. Localized breakdown of a fastener material can be caused by extreme temperature, acids, or other factors. The weakened area becomes the anode and loses metal locally to the passive or cathodic area.

As an example of how pitting becomes localized, consider the action of iron in an oxygen-bearing solution. Iron reacts with the hydroxide radical of water to form ferric hydroxide, freeing a positive hydrogen ion in the solution and a surplus electron in the metal. The positive hydrogen ion unites with oxygen in the solution to form water. Ferric hydroxide tends to flocculate, or collect in random globs on the surface of the metal. The iron underneath these random globs is shielded from the oxygen, and becomes anodic.

A minute flow of electrons actually takes place from the anode to the cathode through the metal. This battery-like action accelerates, eating deeper into the iron, as the precipitated globs get thicker and form a better oxygen shield for the anodic area.

4. **Stress Corrosion:** Stress corrosion, season cracking, or corrosion fatigue is a complicated sequence of corrosion and fracture. Stresses near the yield point of the material stretch the metal and break what protective layer of corrosion product may exist on the surface of the metal. Also, high stresses concentrate in any cracks or capillary spaces near the surface of the metal, opening them up for the concentration-cell corrosion explained in pitting. The corrosive action destroys some part of the material, and the next time the stress is repeated, local stresses are higher and the effect is aggravated until the metal fails.

To eliminate this type of failure, keep stresses low, and avoid sharp corners or other areas where high localized stresses can develop.

5. **Stray Currents:** Buried, or in a solution, fabricated metal sections may come in contact with electric currents caused by extraneous influences such as generators or motors. This can cause accelerated disintegration of the metal.

6. **Dezincification:** This type of corrosion is similar to galvanic corrosion. It occurs in brass that contains more than 15 per cent zinc. In the presence of an electrolyte, the zinc in the alloy goes into solution, followed by a redeposition of porous copper in the metal. This redeposited copper has little mechanical strength, but outwardly the brass product appears to have suffered only minor surface corrosion.

To Minimize Fastener Corrosion:

1. Use fastener metal or alloy most likely to resist the corrosive environment to which it will be subjected.
2. Use metal combinations close together in the galvanic series.
3. Avoid fastener combinations where the area of the less noble material is relatively small.
4. Avoid irregular stresses in design.
5. Paint, coat, or insulate dissimilar metals.
6. Add suitable chemical inhibitors to a corrosive solution, if possible.
7. Keep dissimilar materials far apart if they must be used. Don't join them by threaded connections unless they are insulated.
8. Attach pieces of less noble metal which are not functional to the item to be protected. These can then corrode sacrificially.

DESIGN DATA

CHAPTER 6

Joint Design

TECHNICAL INFORMATION STAFF
Industrial Fasteners Institute, Cleveland, Ohio

MECHANICAL joints can be classified into two categories; those fastened permanently, and those held with removable fasteners.

Permanent fastener joints are produced by riveting, removable joints are usually held with threaded fasteners. Rivets are definitely permanent fasteners and must be destroyed if removed, however, many threaded fasteners are used as permanent fasteners in cases where low volume or other special considerations eliminate the possibility of welding or riveting.

Rivets are usually cheaper than threaded fasteners, and their strength in shear or tension is similar. Threaded fasteners offer the advantage of high clamping forces, and their "in-place" costs may be less than rivets, considering tooling and assembly costs, on a low-volume scale.

Strength Factors: In a well-designed, mechanically fastened joint, strength of connected members and the strength of fasteners are in balance. All joint members including the fasteners may be subjected to tension, torsion, shear, bending stresses, compression stresses, or any or all of these.

The effective cross-sectional area in shear for a rivet is usually considered to be the hole size, except in structural work where it is rivet diameter. For threaded fasteners, the design should be evaluated to see whether the unthreaded body section, Fig. 1, or the threaded section is in shear. The load a fastener can withstand in shear is proportional to the number of shear planes available, Fig. 2.

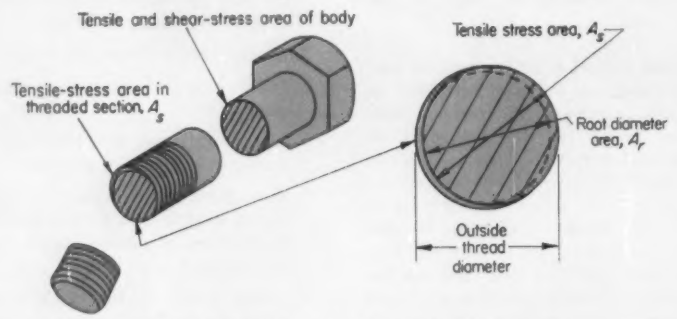

Tensile and shear-stress area of body
Tensile stress area, A_s
Tensile-stress area in threaded section, A_s
Root diameter area, A_r
Outside thread diameter

Fig. 1—If the threaded section of a bolt is subjected to shear stresses, the bolt resists the shear with an area derived from the root diameter of the thread. In tensile stress, the acting bolt area is larger than root diameter area, but smaller than nominal thread-diameter area.

Basic Fastener Equations

To Find	Use
Fastener shear load	$P_s = S_s A n$
Root-diameter area	$A_r = 0.7854 \left(D - \frac{1.3}{N} \right)^2$
Fastener load in tension	$P_t = S_t A$
Tensile-stress area of a threaded section	$A_s = 0.7854 \left(D - \frac{0.9743}{N} \right)^2$

Design of Riveted Joints

Riveting can be done hot or cold. The cold method has replaced hot riveting in

Nomenclature

- A = Effective cross-sectional area, sq in. Use hole size for rivets; use A_r and A_s for threaded fasteners
- A_r = Root diameter area of a threaded section, sq in.
- A_s = Tensile stress area of a threaded section, sq in.
- D = Nominal diameter of fastener, in.
- n = Number of shear planes
- N = Number of shear threads per inch
- P_s = Fastener shear load, lb
- P_t = Fastener load in tension, lb
- S_s = Fastener shear stress, psi
- S_t = Fastener stress in tension, psi

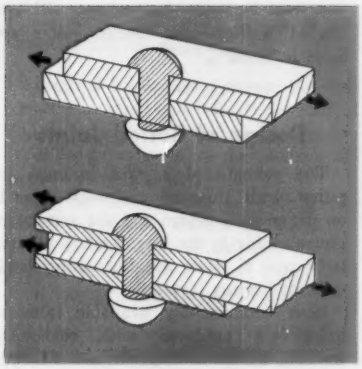


Fig. 2—An increase in the number of shear planes increases the shear load a fastener can safely endure.

many industrial applications because of the speed and efficiency of new riveting tools and the introduction of new rivet materials which are free of scale.

Length of rivet required to form a standard head when the diameter and grip are known is different for the hot and cold methods.

Riveting Processes: One common process of putting a head on a rivet is impact riveting or peening. This method of riveting holds a pin or a rivet in an assembly by swaging the material of the pin or rivet outward and downward into contact with the sides of the hole in which the pin or rivet is to be assembled. The balance of the material in the pin or rivet is swaged into a rough head.

Impact riveting is often used where stock thickness or hardness of parts vary. The operator can control the force and the number of blows required to produce a secure assembly.

Spin riveting is applied where a better head-bearing surface is required than can be obtained with impact or squeeze riveting. In spin riveting, the rivet is prevented from turning while a rotating tool head, with an integral roller face, bears against the rivet and spins out the head. Clamping pressure of the rivet is controlled by the speed at which the tool head spins and the pressure exerted against the rivet head. This method of riveting has less tendency to cause shaft distortion in the rivet. It has the drawback of being slower in operation, and tool cost is high.

Spin riveting offers a design advantage in assemblies where one of the assembled parts must be free to rotate. The minimized rivet body distortion allows movement of the assembled part around the rivet, if the rivet clamping force is held to a low value by the spinning tool.

Squeeze riveting is, as the name implies, a method of forming heads by pressure. Squeezed rivets do not have upset heads; the rivet stem is compressed beyond the elastic limit and bulges out to form a cylinder of larger diameter than the hole.

Squeeze riveting is useful in fastening two or more parts together where the holes for the rivet may be slightly mismatched. Squeeze riveting tends to distort the rivet body below the riveting point and by doing so fills the holes in the plates even though they may be slightly mismatched.

Riveted Joints: Either lap or butt joints, Fig. 3, are generally used in riveted joint designs. In chain-riveted joints, the rivets are in even rows. In stagger-riveted joints, the rows are staggered diagonally.

The centerline through a row of rivets drawn parallel to the joint edge of the plates is known as a gage line. The distance from the edge of the plate to the first gage line is edge distance. Pitch is the distance between rivets. Transverse pitch is the distance between gage lines, and diagonal pitch is the distance between centers of rivets in adjacent rows when staggered or when zigzag riveting is used.

For proper balance of strength, rivet material should be of about the same strength of the material being riveted.

Proper selection of rivet pitch will help avoid tearing of the plate between rivets. Minimum rivet spacing is usually at least three times the rivet diameter. Allow enough room between rivets to permit driving. If pitch is too large, buckling of metal between rivets may occur.

A good rule of thumb to prevent tearing, shearing, or buckling of the plate between the rivet hole and the edge of

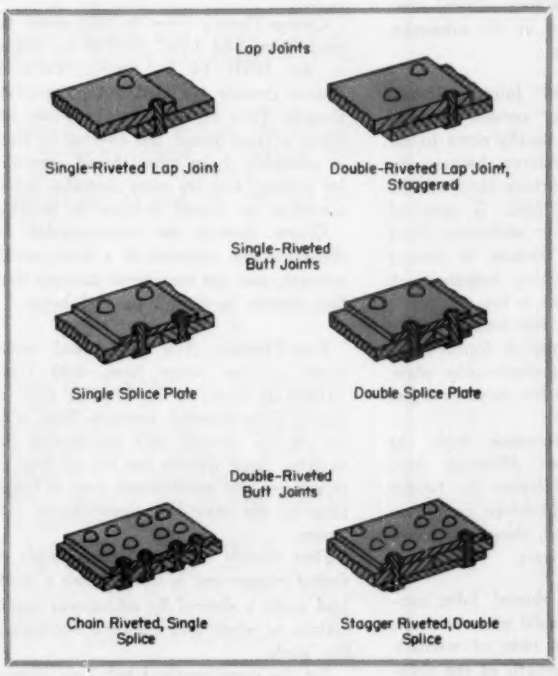


Fig. 3—Types of riveted joints.

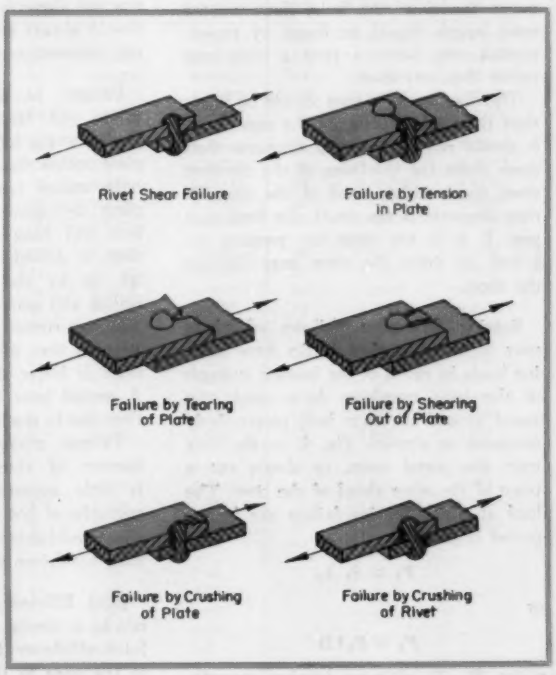

Rivet Shear Failure
Failure by Tension in Plate
Failure by Tearing of Plate
Failure by Shearing Out of Plate
Failure by Crushing of Plate
Failure by Crushing of Rivet

Fig. 4—Riveted joint failures when load is perpendicular to gage line and axis of rivets. The plates are pulled apart by pure tension loading, but the rivets and joints are subjected to combinations of forces as failure occurs.

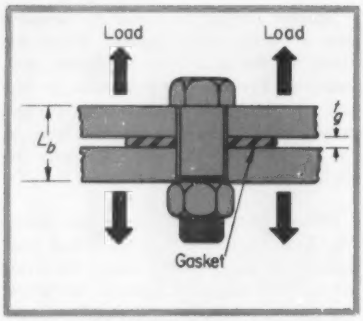


Fig. 5—Use of a gasket in a joint increases the flexibility of a joint and increases the external load felt by a bolt. The effect of external forces increases with a softer gasket.

the sheet is: Keep edge distance at least 1½ times hole diameter.

Hole Size: If the hole is not large enough, it may be difficult to get rivets in the holes. If holes are too large the plates may bulge or separate, the rivets may bend or become eccentric upsets, or the rivets may be loose because they cannot expand enough during riveting to fill the hole. Hole size should be as small as possible, yet large enough to allow quick insertion of the rivet.

Rivet Size: Length of a rivet is determined by the hole size, rivet diameter, type of head, and total thickness of joint being riveted. Rivet manufacturers provide tables of recommended lengths for various head styles and clearances between the rivet and hole, however, the exact length should be found by experimental tests. Select a rivet a little long rather than too short.

The diameter of a rivet should be larger than the thickest plate. At the same time, it should not be larger in diameter than three times the thickness of the thinnest sheet under either head of the rivet. If rivet diameter is too small, the head may pop. If it is too large the pressure required to drive the rivet may damage the sheet.

Bearing Strengths: Failures of plates may occur when rivet bodies have bearing loads in excess of the bearing strength of the joint members. As a result, the metal around the rivet hole progressively elongates or distorts, Fig. 4, or the rivet tears the metal open, or shears out a piece of the plate ahead of the rivet The load at which bearing failure can be expected is given by

$$P_b = S_b A_b$$

or

$$P_b = S_b t D$$

where P_b = ultimate bearing strength of the joint (ultimate bearing load per rivet), lb; S_b = ultimate bearing strength of plate or joint metal against which rivet bears, psi; $A_b = tD$ = area in bearing (projected crushing area of rivet), sq in.; t = thickness of plate in bearing, in.; D = rivet diameter after riveting (actually, hole diameter), in. In structural work, D is taken as nominal diameter of the rivet before driving instead of hole diameter.

A rivet hole may start to distort under a bearing load which is much less than ultimate. Bearing yield strength of aluminum alloys is chosen as that value of bearing stress at which the permanent set in the rivet hole equals 2 per cent of the hole diameter.

Bearing strength calculations for countersunk rivets are the same as those for protruding-head rivets except that the countersunk head will not provide a fully effective bearing area. Avoid designs where the countersink extends completely through the plate thickness.

Plate Tensile Strength: Area of metal between rivets, Fig. 3, resists tensile-load failure. To calculate tensile load which will cause failure of a plate, use

$$P_u = S_u(W - nD)t$$

where P_u = tensile failure load, lb; S_u = ultimate tensile strength of plate, psi; W = width of the plate, in.; n = number of rivets in a transverse row; D = diameter of rivet holes, in.; and t = thickness of plate, in. Actually, the $(W - nD)t$ term is net area of the plate. If the rivet pitch is too small, diameter too big, or plate too thin, the plate or sheet will tear out along the gage line. Calculations should always be based on the minimum net cross-sectional area.

Fatigue in Riveted Joints: Riveted joints will fail under certain repeated loads. Fatigue failures usually occur in the plate rather than the rivets because the holes reduce the endurance limit of the plate by about one-third. A punched hole will have a lower endurance limit than a drilled hole because of stresses set up by the punching operation. A drilled and reamed hole is best.

A butt-riveted joint has greater fatigue strength than a lap joint. A double-splice plate is better than a single-splice plate. A riveted joint in double shear is better than one in single shear.

Fatigue strength increases with the number of rivet rows. Although there is little apparent difference in fatigue strengths of hot or cold-driven aluminum rivets, cold-driven steel rivets are better than hot-driven steel rivets.

Joint Efficiency: A riveted joint cannot be as strong as a solid plate or sheet. Joint efficiency is the ratio of strength of the joint to the strength of the thinnest sheet or plate being joined. To determine the strength of a joint, strength calculations in bearing, shear and tension must be made. Approximate efficiencies of well-designed riveted joints are listed in Table 1.

Design of Bolted Joints

The strength of a joint fastened together with threaded members depends on the over-all design and the amount of pretensioning in the bolt. This is particularly true if there are fluctuating loads or shear loading involved.

Most commercially available fasteners today are produced with cold-rolled threads, which usually increase strength. The increase in static strength is small, but the fatigue strength may increase considerably. This occurs because of residual compressive stresses in the thread root, work hardening, and improvement of grain flow. Much of the beneficial effects of cold working are lost if fastener parts are subsequently heat treated. Some specifications, such as SAE Grade 7, require rolling of threads after the heat treating operation.

Actual shape or form of the threaded members has an effect on thread strength. For example, the bolt shank diameter can be reduced to absorb impact energy, then the shank is stretched at the same rate as the threaded portion. In this case the reduced shank should be as long as possible, and shank area should be about equal to the tensile stress area of the bolt threads.

For best thread matching, the nut material should be somewhat softer than the bolt material.

Coarse-Thread: Sizes in this series extend from 1-64 UNC (0.0730 in. diam) to 4-4 UNC (4 in. diam), Table 2. Coarse threads are used more than fine threads. They are easier to assemble, less likely to cross thread. less affected by burrs in assembly, have more thread clearance for plating, and are more desirable where corrosion or thread damage is possible.

Coarse threads are recommended for threading into materials of a lower tensile strength, and are considered stronger than fine threads in sizes 1 in. and larger.

Fine-Threads: The fine-thread series covers a size range from 0-80 UNF (0.0600 in. diam) to 1½-12 UNF (1½ in. diam). Fine-threaded fasteners find wide use in the aircraft and automotive industries. Since threads are not as deep in this series, the tensile-stress area is larger than in the same-size coarse-thread fasteners.

Fine threads are used where length of thread engagement is short, where a small lead angle is desired for adjustment applications, or where wall thickness demands a fine pitch.

For the same nominal bolt size, clamping force which can be developed by a fine-thread fastener is greater than that of a comparable coarse-thread fastener, pro-

viding thread-engagement length is sufficient to prevent stripping.

Length of Thread Engagement: For steel screws threaded into steel, one rule of thumb is to allow thread engagement to be at least the same as the nominal diameter of the thread.

For cast iron, brass, or bronze, the thread engagement should be about 1½ times the diameter. Aluminum, zinc, or plastics should have a thread engagement of at least 2 times the diameter.

Joint Loading

Tension in a bolt is increased only when the externally applied load exceeds the bolt preload (clamping load).

Actually the preceding statement is not quite true, but it is true enough so that quite adequate designs can be made based on this assumption. According to Hooke's law, deflection is proportional to applied force. If the previous statement were true it would be possible to build an infinitely rigid structure.

In most joints, the ratio of joint rigidity to fastener rigidity is high enough to almost discount any addition to tension already in the bolt produced by any externally applied load. For a more detailed analysis of this problem see "The Prestressed Bolt" by James G. McClure, MACHINE DESIGN, Sept. 15, 1960.

However, in a flexible joint with a soft gasket between bolted parts, Fig. 5, the rigidities of the joint and the bolt are quite different; here, a much greater proportion of the externally applied tension load is added to the bolt preload. The reason for this may become more obvious by studying the following equation:

$$P = P_i + CF_a \qquad (1)$$

where P = final load on the bolt, lb; P_i = initial preload or clamping load developed through tightening, lb; F_a = external applied load, lb; and the constant

$$C = \frac{\dfrac{E_b A_b}{L_b}}{\dfrac{E_b A_b}{L_b} + \dfrac{E_g A_g}{t_g}} \qquad (2)$$

where E_b = modulus of elasticity of the bolt, psi; E_g = modulus of elasticity of the gasket, psi; A_b = effective cross-sectional area of bolt, sq in.; A_g = loaded area of gasket, sq in.; L = effective length of bolt, in.; and t_g = gasket thickness, in.

The valve of the constant C falls between 0 ond 1. The term $E_g A_g/t_g$ in Equation 2 will be large in comparison to $E_b A_b/L_b$ if the gasket is hard, thin, and large in area. Then the constant C approaches zero. When no gasket is used between members in a rigid joint, C = 0. For very soft gaskets, C approaches 1. It is important to remember that Equation 2 is only valid as long as the gasket remains in contact with joint members. If the bolt stretches to the point where the gasket is no longer in contact, Equation 1 (and bolt load) is simply $P = F_a$.

Table 1—Approximate Efficiencies of Riveted Joints

Type of Joint	Efficiency (per cent)
Riveted Butt Joint	
Single	60 to 70
Double	75 to 83
Triple	80 to 89
Riveted Lap Joint	
Single	50 to 60
Double	60 to 70
Triple	70 to 80

Fatigue Effects: The fatigue strength of a bolted joint must be evaluated two ways: Fatigue of the bolt, and fatigue of the bolted material. The properly tightened bolt will not fail in fatigue in a rigid joint. Initial bolt tension will stay relatively constant until the external tension load on the joint exceeds the bolt load. Do not permit the calculated service load to be greater than the high bolt preload. The bolt will experience no appreciable stress variation, and without stress variation, there can be no failure by fatigue. Regardless of the number of load cycles on the joint, the bolt itself is immune to fatigue.

This is not the case where considerable flexibility is present. Variable stress in screw or bolt fastenings increases with the flexibility of the connected parts. If flexibility is too great, the variable stress present may be high enough to cause eventual fatigue failure of the fastener regardless of the initial bolt load.

Selecting joint members which are as rigid as possible and picking fasteners as flexible as possible are important steps to successful bolted joint design using threaded fasteners. Soft materials in joint members may spell trouble unless extra design precautions are taken. Gaskets should be avoided if at all possible. If used, they should be as rigid and as thin as practical.

The most critical points for fastener failure due to fatigue are at the first thread inside the nut, of the junction of the head and shank, and at the thread runout. The place of failure is dependent upon the characteristics of the structural

Table 2—Stress Areas of Unified Screw Threads, UNC and UNF

Size Designation	Nominal Diameter D (in.)	Coarse Series—UNC: Threads per Inch	Coarse Series—UNC: Tensile Stress Area, A_s (sq in.)	Coarse Series—UNC: Sectional Area at Minor Diameter, A_r (sq in.)	Fine Series—UNF: Threads per Inch	Fine Series—UNF: Tensile Stress Area, A_s (sq in.)	Fine Series—UNF: Sectional Area at Minor Diameter, A_r (sq in.)
0	0.0600	..	.....	.....	80	0.00180	0.00151
1	0.0730	64	0.00263	0.00218	72	0.00278	0.00237
2	0.0860	56	0.00370	0.00310	64	0.00394	0.00339
3	0.0990	48	0.00487	0.00406	56	0.00523	0.00451
4	0.1120	40	0.00604	0.00496	48	0.00661	0.00566
5	0.1250	40	0.00796	0.00672	44	0.00830	0.00716
6	0.1380	32	0.00909	0.00745	40	0.01015	0.00874
8	0.1640	32	0.0140	0.01196	36	0.01474	0.01285
10	0.1900	24	0.0175	0.01450	32	0.0200	0.0175
12	0.2160	24	0.0242	0.0206	28	0.0258	0.0226
¼	0.2500	20	0.0318	0.0269	28	0.0364	0.0326
5/16	0.3125	18	0.0524	0.0454	24	0.0580	0.0524
⅜	0.3750	16	0.0775	0.0678	24	0.0878	0.0809
7/16	0.4375	14	0.1063	0.0933	20	0.1187	0.1090
½	0.5000	13	0.1419	0.1257	20	0.1599	0.1486
9/16	0.5625	12	0.182	0.162	18	0.203	0.189
⅝	0.6250	11	0.226	0.202	18	0.256	0.240
¾	0.7500	10	0.334	0.302	16	0.373	0.351
⅞	0.8750	9	0.462	0.419	14	0.509	0.480
1	1.0000	8	0.606	0.551	12	0.663	0.625
1⅛	1.1250	7	0.763	0.693	12	0.856	0.812
1¼	1.2500	7	0.969	0.890	12	1.073	1.024
1⅜	1.3750	6	1.155	1.054	12	1.315	1.260
1½	1.5000	6	1.405	1.294	12	1.581	1.521
1¾	1.7500	5	1.90	1.74	..	....	....
2	2.0000	4½	2.50	2.30	..	....	....
2¼	2.2500	4½	3.25	3.02	..	....	....
2½	2.500	4	4.00	3.72	..	....	....
2¾	2.750	4	4.93	4.62	..	....	....
3	3.000	4	5.97	5.62	..	....	....
3¼	3.250	4	7.10	6.72	..	....	....
3½	3.500	4	8.33	7.92	..	....	....
3¾	3.750	4	9.66	9.21	..	....	....
4	4.000	4	11.08	10.61	..	....	....

elements joined by the bolt and nut.

The greatest single factor which can eliminate cyclic stress variation due to cyclic loading is proper pretensioning or preloading of the fastener. Test results indicate that rigid members bolted together by relatively elastic bolts offer the best result to prevent fatigue failure.

Clamping Load: In the design of a rigid bolted joint, the most important consideration from a functional standpoint is the initial clamping force developed by the bolt. When two relatively rigid plates are clamped together by a bolt pretensioned to 10,000 lb, the plates are held together just as if a 5-ton weight were sitting on them, and any force less than 10,000 lb will not be able to pull them apart.

Obviously, the reason for developing a high preload in the bolt and joint assembly is to make a stronger joint. As preload goes up, the fasteners in the joint can withstand higher static or cyclic loads which may be trying to pull, bend, or shear the joint apart.

Safety Factor: If a bolt is selected with a yield strength that is 4 times the working load, it does not necessarily follow that the design will have a safety factor of 4. In a rigid joint, only when the bolt is tightened to develop a clamping force 4 times the working load is a safety factor of 4 achieved.

Flexible joints are quite different. A flexible joint can only be tightened to the working load. In the case of a flexible joint, a bolt must be selected to meet the requirements of the working load plus any added stress, all multiplied by the required factor of safety.

If a bolt doesn't fail in being wrenched up tight, it will not fail in service, assuming bolts and joint have been designed adequately for the loads. When the bolt is tightened, there is a combined stress compounded of axial tension due to clamping and torsion due to frictional drag on the threads. The bolt may break during tightening due to this combined stress, but at the time of failure the tensile component is only about 80 per cent of the ultimate strength of the bolt. If the bolt is tightened just to the point of failure and the wrench is removed, the torsional component quickly disappears, leaving only the axial tensile stress. Thus, when the service loads come onto the joint, some 20 per cent of the bolt strength is still available.

Bolt Tension by Elongation: One method of determining initial bolt tension or preload is to measure the actual change in length of the bolt. Often this is simply impossible because one end may not be accessible or the bolt might be used to join a large flat section.

If elongation is known, fastener stress can be calculated. Stress is directly proportional to the modulus of elasticity and the elongation, and inversely proportional to the length. Only the section of the bolt between the nut and head stretches, but how far into the nut and how far into the head is the question. There is no pat answer for this; each application must be separately evaluated.

Bolt Torque

Joint strength is affected more by clamping force than by rated tensile strength of the bolt, and clamping force is proportional to tightening torque. The following four methods are commonly used to tighten a bolt to a specific torque:

1. Manual torque wrenching. This is the oldest means of tightening bolts. The torque wrench is designed with a torque-indicating dial as part of the wrench.
2. Pneumatic impact wrenching. In this torquing technique, air pressure is carefully controlled, so that the wrench stalls when the desired tension is reached.
3. Pneumatic impact wrenching, using automatic cutoff. This type of tool is designed with a built-in device which automatically shuts off air supply when proper torque is obtained.
4. Turn-of-nut method. This is one of the simplest methods used. The nut is turned to an initial tightness, often referred to as finger tight. Then the nut, or the head of the bolt, is given

Table 3—Suggested Maximum Torque Values for Fasteners of Different Materials

	Maximum Torque (lb-in.)						
Bolt Size	Aluminum 2024-T4	Brass	Monel	Silicon Bronze	Steel, Low-Carbon	Steel, 18-8 Stainless	Steel, 316 Stainless
2-56	1.4	2.0	2.5	2.3	2.2	2.5	2.6
2-64	1.7	2.5	3.1	2.8	2.7	3.0	3.2
3-48	2.1	3.2	4.0	3.6	3.5	3.9	4.0
3-56	2.4	3.6	4.5	4.1	4.0	4.4	4.6
4-40	2.9	4.3	5.3	4.8	4.7	5.2	5.5
4-48	3.6	5.4	6.7	6.1	5.9	6.6	6.9
5-40	4.2	6.3	7.8	7.1	6.9	7.7	8.1
5-44	5.1	7.7	9.6	8.7	8.5	9.4	9.8
6-32	5.3	7.9	9.8	8.9	8.7	9.6	10.1
6-40	6.6	9.9	12.3	11.2	10.9	12.1	12.7
8-32	10.8	16.2	20.2	18.4	17.8	19.8	20.7
8-36	12.0	18.0	22.4	20.4	19.8	22.0	23.0
10-24	13.8	18.6	25.9	21.2	20.8	22.8	23.8
10-32	19.2	25.9	34.9	29.3	29.7	31.7	33.1
1/4"-20	45.6	61.5	85.3	68.8	65.0	75.2	78.8
1/4"-28	57.0	77.0	106.0	87.0	90.0	94.0	99.0
5/16"-18	80	107	149	123	129	132	138
5/16"-24	86	116	160	131	139	142	147
3/8"-16	143	192	266	219	212	236	247
3/8"-24	157	212	294	240	232	259	271
7/16"-14	228	317	427	349	338	376	393
7/16"-20	242	327	451	371	361	400	418
1/2"-13	313	422	584	480	465	517	542
1/2"-20	328	443	613	502	487	541	565
9/16"-12	413	558	774	632	613	682	713
9/16"-18	456	615	855	697	668	752	787
5/8"-11	715	907	1330	1030	1000	1110	1160
5/8"-18	798	1016	1482	1154	1140	1244	1301
5/8"-10	980	1249	1832	1416	1259	1530	1582
5/8"-16	958	1220	1790	1382	1230	1490	1558
7/8"-9	1495	1905	2775	2140	1919	2328	2430
7/8"-14	1490	1895	2755	2130	1911	2318	2420
1"-8	2205	2815	4130	3185	2832	3440	3595
1"-14	1995	2545	3730	2885	2562	3110	3250
	Maximum Torque (lb-ft.)						
1 1/16"-7	265	337	499	383	340	413	432
1 1/16"-12	251	318	470	361	322	390	408
1 1/4"-7	336	428	627	485	432	523	546
1 1/4"-12	308	394	575	447	396	480	504
1 1/2"-6	570	727	1064	822	732	888	930
1 1/2"-12	450	575	840	651	579	703	732

Data, courtesy H. M. Harper Co. The torque values given here are to be used only as a guide for noncritical torquing application.

These values should develop bolt tension to slightly less than yield point. Ordinary dial type torque-wrench equipment was used in plotting torque value curves. Fasteners were torqued to failure in all cases. Washers were used only underneath the nut end. Fastener was brought under tension at point where nut would be mid-way in threaded section.

a specified amount of turn with the wrench. The amount of turn varies widely, depending on bolt length, diameter, material, thread pitch, and joint characteristics.

There can be large variations in the tension produced in a bolt by these torquing techniques. Many manufacturers swear by torque wrenches, whereas others feel an experienced mechanic is better than the best torque wrench made.

The secret of successful use of a torque wrench lies in uniformity of bolted surfaces and the bolts themselves, plus a carefully calibrated torque wrench. In the use of torque wrenches, the proper torque-tension relationships should be determined through torque-to-yield or torque-to-failure tests.

Approximately 90 per cent of the torque applied in tightening a bolt is used in overcoming friction. Since the friction factor varies with the amount of scale on the nut, plating, lubrication, etc., the exact amount of torque needed to produce a given tension is very difficult to predict. However, bolt tension or clamping load can be calculated with the following formula:

$$T = KDP$$

where T = torque, lb-in.; K = torque coefficient; D = nominal bolt diameter, in.; and P = bolt tension or clamping load, lb. Torque calculations for a given clamping load P can be made very accurately by hand or by machine. Slide-rule accuracy of T values can be obtained from the nomograph. Suggested tightening torque values for ferrous and nonferrous materials are given in Table 3.

The coefficient K with normally dry surfaces and normal unlubricated bolts and nuts is usually about 0.2. There can be considerable variation, and this value should be used only as a preliminary estimate. Lubrication will reduce tthis value.

The more exact value of K, assuming no thread interference such as produced by a locknut or an interference-fit thread, is expressed by

$$K = \frac{\mu_B R_B}{D} + \frac{R_T}{D}\left(\frac{\mu_T \sec B + \tan C}{1 - \mu_T \sec B \tan C}\right)$$

where μ_B = coefficient of friction at bearing face of nut or bolt; μ_T = coefficient of fraction at thread contract surfaces; R_B = effective radius of action of frictional forces on bearing face, in.; R_T = effective radius of action of frictional forces on thread surfaces, in.; B = thread half-angle (30 deg for 60 deg thread; sec B = 1.15); and C = helix angle of thread.

For threads normally used for fasteners, the denominator of the bracketed term is one within ½ per cent, so that the equation simplifies to

$$K = u_B \frac{R_B}{D} + u_T \frac{R_T}{D} \sec B + \frac{R_T}{D} \tan C$$

or

$$K = K_1 + K_2 + K_3$$

The relative values of K_1, K_2, and K_3 can be studied by using the following average values: R_B/D = 0.65; $\mu_B = \mu_T$ = 0.15; R_T/D = 0.45; sec B = 1.15; tan C = 0.04.

$$K = 0.098 + 0.078 + 0.018 = 0.194$$

$$\frac{100K}{0.194} = 50.5\% + 40.2\% + 9.3\% = 100\%$$

Therefore, K_1 contributes roughly 50 per cent to the torque coefficient K; whereas K_2 contributes 40 per cent; and K_3, 10 per cent.

Coefficient K_1 represents the unit torque wasted by friction on the bearing face of the nut or bolt. The value of K_1 varies with the coefficient of bearing face friction (0.12-0.20) and also with the effective radius of the bearing face, R_B. Radius R_B is approximately the average radius of the bearing face if the contact pressure is uniform. If the bearing face is not true and flat and the pressure uniform, R_B may vary from the inner radius of the bearing face to the outer radius.

Coefficient K_2 takes care of the unit torque wasted by friction on the contact flanks of the threads, about 40 per cent of the total torque. K_2 also varies with the coefficient of thread friction and with the radius of effective action of friction on the thread faces, R_T. Radius R_T is approximately the pitch radius of the screw thread if thread contact pressure is uniform. If contact pressure is not uniform, R_T may vary from the inner to the outer radius of the contact of thread. Radius R_T will also differ between coarse threads and fine threads, being larger for fine threads, resulting in a higher torque. K_2 varies slightly with the amount of bolt tension because of the increased angle B due to thread bending under load. The increase in angle B may be considerable at loads near thread failure by stripping.

Coefficient K_3 represents the useful, torque-producing bolt tension, about 10 per cent of the total torque. K_3 varies with R_T and with the helix angle of the thread which varies with bolt size and is somewhat larger for smaller bolts. K_3 also varies between coarse and fine threads, being slightly larger for coarse threads.

Table 4 shows values of K as computed by Equation 2 using $\mu_B = \mu_T$ = 0.15; R_B = average radius for regular semi-finished hexagon nuts; R_T = pitch radius of threads; sec B = 1.15; tan C = value for appropriate thread. This table also shows experimental values determined from a large number of bolts from several different manufacturers. As shown, agreement between computed and average experimental values is close. Table 5 gives a list of calculated torque coefficients for finished hexagon nuts, finished hexagon bolts, and heavy hexagon bolt

Table 4—Calculated and Measured Torque Coefficients, K

Bolt Size	Calculated K for Semifinished Hexagon Nuts*	Measured K (average)	
		High-Point Torque	Mid-Point Torque
¼-20	0.210	0.243	0.267
¼-28	0.205	0.216	0.231
5/16-18	0.210	0.206	0.186
5/16-24	0.205	0.194	0.183
⅜-16	0.204	0.200	0.247
⅜-24	0.198	0.192	0.234
7/16-14	0.205	0.217	0.224
7/16-20	0.200	0.194	0.190
½-13	0.201	0.205	0.158
½-20	0.195	0.167	0.205
9/16-12	0.198	0.194	0.214
9/16-18	0.193	0.196	0.207
⅝-11	0.199	0.178	0.196
⅝-18	0.193	0.183	0.175
¾-10	0.194	0.169	0.172
¾-16	0.189	0.170	0.180
⅞-9	0.194	0.181	0.194
⅞-14	0.189	0.171	0.178
1-8	0.193	0.188	0.204
1-14	0.188	0.161	0.167
Average	0.198	0.191	0.201

*Computed with a coefficient of friction of 0.15 and the dimensions of American Standard Hexagon Nuts.

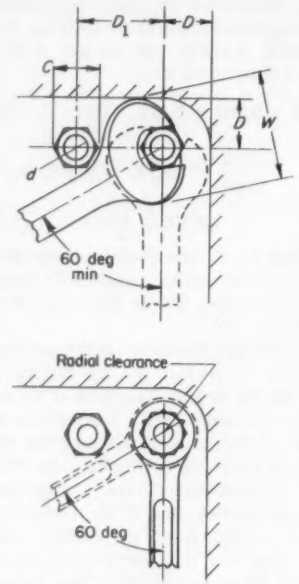


Fig. 6—Allow sufficient clearance in a bolted assembly for at least 60 deg of wrench movement.

or nut combinations.

One sure way to check tightening torque is in a pilot assembly with accurate torque-tension test equipment. Another technique is to pilot-test rigid joints by tightening a few bolts with a torque wrench until they fail. The specified tightening torque value can then be set at 75 or 80 per cent of that load. Sometimes a torque value is set at the yield point of a bolt, since the torsion component vanishes after the bolt is tightened.

Selecting Bolt Grades: Where standard steel bolts or cap screws can meet environmental requirements of a design, SAE Grades 1, 2, and 5 can satisfy most conventional "clamping" fastener applications. As shown in Table 6, SAE Grade 1 provides a minimum tensile strength of 55,000 psi, Grade 2 offers a 69,000 psi minimum tensile strength up to ½-in. diam, and Grade 5 approximately 120,000 psi up to ¾-in. diam.

Grade 1 fasteners are made of low-carbon commercial steel. Grade 2 fasteners are made of low-carbon steel and have a bright finish, and Grade 5 is a medium-carbon, heat-treated fastener which is identifiable by three radial dashes on the head.

In terms of holding power (clamping force), high-strength bolts and cap screws often cost less than low-carbon, nonheat-treated fasteners. For example, either a ⅝-in. Grade 5 bolt or a ¾-in. Grade 2 bolt could be used for a safe working load of 17,000 lb. As shown in Table 2, the proof load of a coarse-thread, ⅝-in., Grade 5 bolt is 19,200 lb, and it has a minimum tensile strength of 27,000 lb. These data are for coarse threads. The Grade 5 bolt has a smaller diameter and costs less. Where this is the case, it is more economical throughout to use the smaller diameter bolt. In short, more pounds of clamping effort are obtained per dollar when using fasteners with higher strength ratings. If more fasteners per dollar are desired, the lower grades of fasteners may be used.

Another advantage of using smaller higher-strength fasteners is that their smaller heads and nuts provide more clearance. Holes in joint members are smaller, which often means they are faster and less expensive to drill. Smaller holes weaken the bolted joint members less, increasing the strength of the joint. When fastener size is smaller, size of joint members can be reduced. Actual cost of the higher-grade fastener may be more even in a smaller size, but the saving in reduction of joint-member size may more than offset the increase in cost.

Spacing: Allowance should be made for the handle of a wrench to turn a minimum of 60 degrees, Fig. 6. Clearances for open-end wrenches may be obtained from

$$D(\text{min}) = \frac{W}{2}$$

$$D_1 = \frac{W + C + d}{2}$$

where D = Distance from center of bolt to nearest side of object as shown in Fig. 6, in.; D_1 = Distance between centers of adjacent bolts, in.; d = Diameter of bolt, in.; C = Distance across corners of nut, in.; and W = Maximum width of wrench head, in. (A value of W equal to $3.5\ d + \frac{1}{8}$-in. will be ample for the majority of wrenches now on the market.) These values are minimum and should be larger wherever practicable.

If possible, the exact tools used in assembly should be measured or their dimensions determined in some other way to know the exact space requirements of the tool in its normal operation.

Loading: Threaded fasteners are, more and more, being used as tension members only. By using a high preload in the fastener, and consequently getting a high clamping force, the coefficient of friction between two plates is enough to keep them from sliding with respect to one

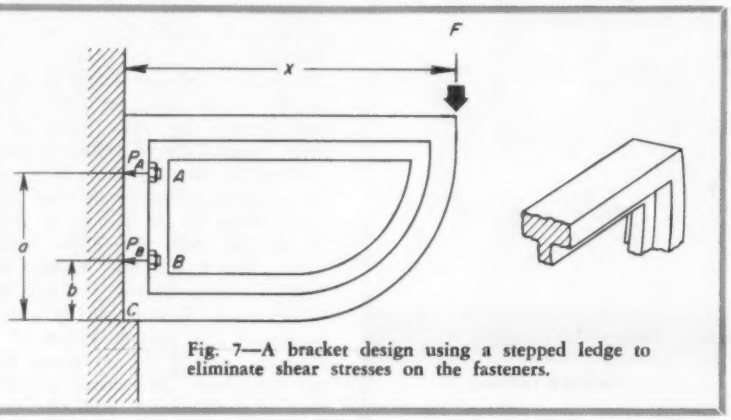


Fig. 7—A bracket design using a stepped ledge to eliminate shear stresses on the fasteners.

Table 5—Calculated Torque Coefficients, *K*

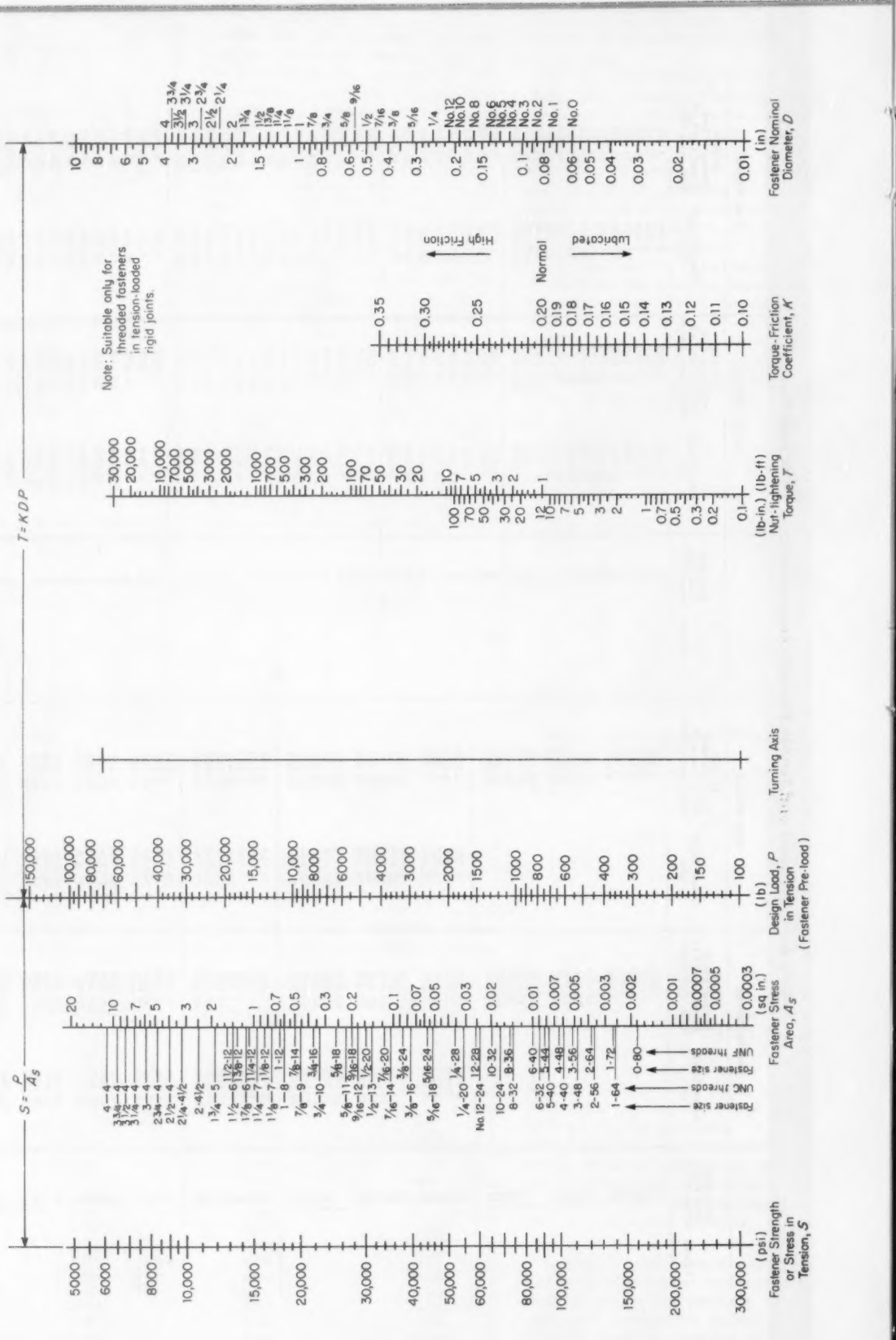
Size	Finished Hex. Nut	Finished Hex. Bolt	Heavy Hex. Bolt or Nut
¼-20	0.213	0.213	0.223
¼-28	0.207	0.207	0.218
5/16-18	0.204	0.204	0.213
5/16-24	0.200	0.200	0.208
⅜-16	0.199	0.199	0.213
⅜-24	0.193	0.193	0.207
7/16-14	0.201	0.196	0.207
7/16-20	0.196	0.190	0.202
½-13	0.198	0.198	0.208
½-20	0.192	0.192	0.203
9/16-12	0.199	0.195	0.202
9/16-18	0.194	0.191	0.197
⅝-11	0.196	0.196	0.205
⅝-18	0.191	0.191	0.199
¾-10	0.195	0.195	0.203
¾-16	0.190	0.190	0.198
⅞-9	0.194	0.194	0.201
⅞-14	0.190	0.190	0.196
1-8	0.194	0.194	0.200
1-14	0.189	0.189	0.194
Average	0.197	0.196	0.205

Table 6—Proof Load and Tensile Strength Requirements of Bolts and Studs

Grade	Bolt and Stud Size Diam (in.)	Coarse Thread: Proof Load (lb)	Coarse Thread: Tensile Strength and Proof Load of Nuts, min (lb)*	Fine Thread: Proof Load (lb)	Fine Thread: Tensile Strength and Proof Load of Nuts, min (lb)*
1	¼	....	1,750	....	2,000
	5/16	....	2,900	....	3,200
	3/8	....	4,250	....	4,850
	7/16	....	5,850	....	6,550
	½	....	7,800	....	8,800
	9/16	....	10,000	....	11,150
	5/8	....	12,450	....	14,100
	¾	....	18,350	....	20,500
	7/8	....	25,400	....	28,000
	1	....	33,350	....	36,450
	1⅛	....	41,950	....	47,100
	1¼	....	53,300	....	59,000
	1⅜	....	63,550	....	72,350
	1½	....	77,300	....	86,950
2	¼	1,750	2,200	2,000	2,500
	5/16	2,900	3,600	3,200	4,000
	3/8	4,250	5,350	4,850	6,050
	7/16	5,850	7,350	6,550	8,200
	½	7,800	9,800	8,800	11,050
	9/16	9,450	11,650	10,550	13,000
	5/8	11,750	14,450	13,300	16,400
	¾	17,350	21,400	19,400	23,850
	7/8	12,900	25,400	14,250	28,000
	1	16,950	33,350	18,550	36,450
	1⅛	21,350	41,950	23,950	47,100
	1¼	27,100	53,300	29,950	59,000
	1⅜	32,300	63,550	36,800	72,350
	1½	39,300	77,300	44,000	86,950
3	¼	2,700	3,500	3,100	4,000
	5/16	4,450	5,750	4,950	6,400
	3/8	6,600	8,550	7,450	9,650
	7/16	9,050	11,700	10,100	13,050
	½	12,050	15,600	13,550	17,550
	9/16	14,550	18,200	16,250	20,300
	5/8	18,100	22,600	20,500	25,600
4 (for studs only)	¼	3,200	3,650	3,650	4,200
	5/16	5,250	6,050	5,800	6,650
	3/8	7,750	8,900	8,800	10,100
	7/16	10,650	12,200	11,850	13,650
	½	14,200	16,300	16,000	18,400
	9/16	18,200	20,950	20,300	23,350
	5/8	22,600	26,000	25,600	29,450
	¾	33,400	38,400	37,300	42,900
	7/8	46,200	53,150	50,900	58,550
	1	60,600	69,700	66,300	76,250
	1⅛	76,300	87,750	85,600	98,450
	1¼	96,900	111,450	107,300	123,400
	1⅜	115,500	132,850	131,500	151,250
	1½	140,500	161,600	158,100	181,800
	1¾	190,000	218,500	219,000	251,850
	2	250,000	287,500	289,000	332,350

Grade	Bolt and Stud Size Diam (in.)	Coarse Thread: Proof Load (lb)	Coarse Thread: Tensile Strength and Proof Load of Nuts, min (lb)*	Fine Thread: Proof Load (lb)	Fine Thread: Tensile Strength and Proof Load of Nuts, min (lb)*
5	¼	2,700	3,800	3,100	4,350
	5/16	4,450	6,300	4,950	6,950
	3/8	6,600	9,300	7,450	10,550
	7/16	9,050	12,750	10,100	14,250
	½	12,050	17,050	13,600	19,200
	9/16	15,450	21,850	17,250	24,350
	5/8	19,200	27,100	21,750	30,700
	¾	28,400	40,100	31,700	44,750
	7/8	36,050	53,150	39,700	58,550
	1	47,250	69,700	51,700	76,250
	1⅛	56,450	80,100	63,350	89,900
	1¼	71,700	101,750	79,400	112,650
	1⅜	85,450	121,300	97,300	138,100
	1½	103,950	147,550	117,000	166,000
6	¼	3,500	4,450	4,000	5,100
	5/16	5,750	7,350	6,400	8,100
	3/8	8,550	10,850	9,650	12,300
	7/16	11,700	14,900	13,050	16,600
	½	15,600	19,850	17,600	22,400
	9/16	20,000	25,500	22,350	28,400
	5/8	24,850	31,650	28,150	35,850
	¾	35,050	44,400	39,150	49,600
7	¼	3,400	4,250	3,800	4,850
	5/16	5,500	6,950	6,100	7,700
	3/8	8,150	10,300	9,200	11,700
	7/16	11,150	14,150	12,450	15,800
	½	14,900	18,850	16,800	21,250
	9/16	19,100	24,200	21,300	27,000
	5/8	23,750	30,050	26,900	34,050
	¾	35,050	44,400	39,150	49,600
	7/8	48,500	61,450	53,450	67,700
	1	63,650	80,600	69,600	88,200
	1⅛	80,100	101,500	89,900	113,850
	1¼	101,750	128,900	112,650	142,700
	1⅜	121,300	153,600	138,100	174,900
	1½	147,550	186,850	166,000	210,250
8	¼	3,800	4,750	4,350	5,450
	5/16	6,300	7,850	6,950	8,700
	3/8	9,300	11,650	10,550	13,150
	7/16	12,750	15,950	14,250	17,800
	½	17,050	21,300	19,200	24,000
	9/16	21,850	27,300	24,350	30,450
	5/8	27,100	33,900	30,700	38,400
	¾	40,100	50,100	44,750	55,950
	7/8	55,450	69,300	61,100	76,350
	1	72,700	90,900	79,550	99,450
	1⅛	91,550	114,450	102,700	128,400
	1¼	116,300	145,350	128,750	160,950
	1⅜	138,600	173,250	157,800	197,250
	1½	168,600	210,750	189,700	237,150

*Tensile strength is the ultimate breaking load of the bolt in a testing machine and equals the proof load of the nut.


T = KDP
S = P/A_s
Fastener Strength or Stress in Tension, S (psi)
Fastener Stress Area, A_s (sq in.)
Design Load, P in Tension (Fastener Pre-load) (lb)
Turning Axis
Nut-tightening Torque, T (lb-in.) (lb-ft)
Torque-Friction Coefficient, K
Fastener Nominal Diameter, D (in)
Note: Suitable only for threaded fasteners in tension-loaded rigid joints.
High Friction
Normal
Lubricated
UNC threads
UNF threads
Fastener size

Mechanical Fastener Nomograph

The Fastener Nomograph is designed to help find approximate fastener tensile strength requirements, nominal fastener sizes, and nut-tightening torques for rigid bolted joints. Data are generally applicable to Unified Standard coarse and fine-thread bolts. Tensile strength is based on the strength of the threaded section.

The nomograph is divided into two sections. The left section permits selection of approximate nominal size for a given preload and a given fastener strength value.

Many different recommendations are made for selecting usable fastener strength, i.e., how much tensile load a fastener can safely take. One recommendation is 2/3 of ultimate tensile strength; another is 75 per cent of proof-load values.

At least one fastener manufacturer recommends that for all general rigid-joint applications, a bolt should be selected based on 80 per cent of the clamping force and tightened with a torque wrench to a value based upon 80 per cent of the minimum yield strength.

For example, assume that fastener design load in a bolted joint is 8000 lb. Since friction conditions can vary as much as 20 per cent, assume the 8000 lb represents 80 per cent of clamping force. This means average clamping force is 10,000 lb. Assume the minimum yield strength of the fastener material being considered is 100,000 psi or, using 80 per cent of this value, 80,000 psi.

Draw line between 80,000 psi on *S* (step 1) and 10,000 lb on *P* (step 2). The answer, on scale *A* (step 3) is between 7/16 and ½ in. diam. The next larger size, ½ in., should be chosen.

To determine the tightening torque required to develop a 10,000-lb clamping load, move to the right side of the nomograph.

Assume a normal torque-friction coefficient value of 0.2 (step 4) and draw line to 10,000 lb on the *P* scale. Swing around the point of intersection (step 5) on the turning axis to point on the *D* scale for a ½-in. diameter (step 6). Read required tightening torque (step 7) which is slightly over 80 lb-ft.

Note that this amount of tightening would be expected to develop the required 10,000-lb clamping force, but the stress on the fastener would be less than 70,000 psi. The reason is that the next larger size fastener was selected. To develop 80,000 psi stress in a ½-in. diameter, coarse-thread fastener, the nomograph shows it would have to be tightened to a clamping load value of about 11,500 lb. Connecting this value of *P* to a 0.2 *K* value and turning the straight edge to a ½-in. diameter value on the *D* gives a tightening torque of approximately 90 lb-ft.

The torque-friction coefficient *K* in the chart for normal conditions on joint surfaces, heads, and threads is usually taken as 0.2. For lubricated or waxed threads, *K* might have a value of 0.15 or lower. Plating, dimensions, hardness, etc., can also affect *K*.

Since as much as 90 per cent of the torque applied in nut tightening is required to overcome friction, changes in joint assembly conditions can cause a wide variation in the friction constant. Even under carefully controlled joint assembly conditions, fastener clamping force can be expected to vary as much as ±20 per cent.

Data for critical fastener applications should be carefully determined and checked under actual joint conditions. One technique is to tighten a few fasteners under actual joint conditions with a torque wrench. Notice when each fastener yields as indicated by no further increase in torque reading while tightening. Each time this happens, remove the bolt and check strength or hardness. Then reduce the torque reading in proportion to the minimum strength or hardness specifications of the bolt. Further reduce the average of all bolts tested by 20 per cent to obtain a minimum yield torque value. If fastener friction conditions are normal, the resulting torque will be the same as found using the normal torque-friction coefficient value of 0.2. If not, determine from the nomograph the resulting torque. A new friction coefficient for the actual joint tightening conditions can be found and used under the same conditions.

The nomograph does not apply for flexible (gasketed) joints or dynamically loaded joints where working load equals or exceeds the preload.

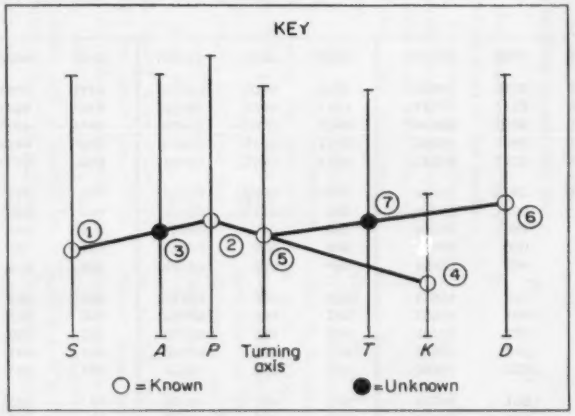


Table 7—Suggested Tightening Torque[1] Values To Produce Corresponding Bolt Clamping Loads

Size	Bolt Diam, D (in.)	Tensile Stress Area, A_s (sq in.)	SAE Grade 2 Bolts					SAE Grade 5 Bolts					SAE Grade 6 and 7[3]			SAE Grade 8[4]		
			Tensile Strength (min psi)	Proof Load (psi)	Clamp[2] Load P (lb)	Tightening Torque Dry K=0.20	Tightening Torque Lub. K=0.15	Tensile Strength (min psi)	Proof Load (psi)	Clamp[2] Load P (lb)	Tightening Torque Dry K=0.20	Tightening Torque Lub. K=0.15	Clamp[2] Load P (lb)	Tightening Torque Dry K=0.20	Tightening Torque Lub. K=0.15	Clamp[2] Load P (lb)	Tightening Torque Dry K=0.20	Tightening Torque Lub. K=0.15
						lb in.	lb in.				lb in.	lb in.		lb in.	lb in.		lb in.	lb in.
4-40	0.1120	0.00604	69,000	55,000	240	5	4	120,000	85,000	380	8	6	480	11	8	540	12	9
4-48	0.1120	0.00661			280	6	5			420	9	7	520	12	9	600	13	10
6-32	0.1380	0.00909			350	10	8			580	16	12	720	20	15	820	23	17
6-40	0.1380	0.01015			420	12	9			640	18	13	800	22	17	920	25	19
8-32	0.1640	0.01400			580	19	14			900	30	22	1100	36	27	1260	41	31
8-36	0.1640	0.01474			600	20	15			940	31	23	1160	38	29	1320	43	32
10-24	0.1900	0.01750			720	27	21			1120	43	32	1380	52	39	1580	60	45
10-32	0.1900	0.02000			820	31	23			1285	49	36	1580	60	45	1800	68	51
¼-20	0.2500	0.0318			1320	66	49			2020	96	75	2500	120	96	2860	144	108
¼-28	0.2500	0.0364			1500	76	56			2320	120	86	2860	144	108	3280	168	120
						lb ft	lb ft				lb ft	lb ft		lb ft	lb ft		lb ft	lb ft
5/16-18	0.3125	0.0524			2160	11	8			3340	17	13	4120	21	16	4720	25	18
5/16-24	0.3125	0.0580			2400	12	9			3700	19	14	4560	24	18	5220	25	20
⅜-16	0.3750	0.0775			3200	20	15			4940	30	23	6100	40	30	7000	45	35
⅜-24	0.3750	0.0878			3620	23	17			5600	35	25	6900	45	30	7900	50	35
7/16-14	0.4375	0.1063			4380	30	24			6800	50	35	8400	60	45	9550	70	55
7/16-20	0.4375	0.1187			4900	35	25			7550	55	40	9350	70	50	10700	80	60
½-13	0.5000	0.1419			5840	50	35			9050	75	55	11200	95	70	12750	110	80
½-20	0.5000	0.1599			6600	55	40			10700	90	65	12600	100	80	14400	120	90
9/16-12	0.5625	0.1820	64,000	52,000	7100	65	50			11600	110	80	14350	135	100	16400	150	110
9/16-18	0.5625	0.2030			7900	75	55			12950	120	90	16000	150	110	18250	170	130
⅝-11	0.6250	0.2260			8800	90	70			14400	150	110	17800	190	140	20350	220	170
⅝-18	0.6250	0.2560			10000	100	80			16950	180	130	20150	210	160	23000	240	180
¾-10	0.7500	0.3340			13000	160	120			21300	260	200	26300	320	240	30100	380	280
¾-16	0.7500	0.3730			14550	180	140			23800	300	220	29400	360	280	33600	420	320
⅞- 9	0.8750	0.4620	55,000	28,000	9700	140	110	115,000	78,000	27000	400	306	36400	520	400	41600	600	460
⅞-14	0.8750	0.5090			10700	155	120			29800	440	320	40100	580	440	45800	660	500
1- 8	1.0000	0.6060			12700	220	160			35500	580	440	47700	800	600	54500	900	680
1-12	1.0000	0.6630			13900	240	170			38800	640	480	52200	860	660	59700	1000	740
1⅛- 7	1.1250	0.7630			16000	300	220	105,000	74,000	42300	800	600	60100	1120	840	68700	1280	960
1⅛-12	1.1250	0.8560			18000	340	260			47500	880	660	67400	1260	940	77000	1440	1080
1¼- 7	1.2500	0.9690			20350	420	320			53800	1120	840	76300	1580	1100	87200	1820	1360
1¼-12	1.2500	1.0730			22550	460	360			59600	1240	920	84500	1760	1320	96600	2000	1500
1⅜- 6	1.3750	1.1550			24300	560	420			64100	1460	1100	91000	2080	1560	104000	2380	1780
1⅜-12	1.3750	1.3150			27600	640	460			73000	1680	1260	104000	2380	1780	118400	2720	2040
1½- 6	1.5000	1.4050			29800	740	560			78000	1940	1460	111000	2780	2080	126500	3160	2360
1½-12	1.5000	1.5800			33200	840	620			87700	2200	1640	124005	3100	2320	142200	3560	2660

Notes:
1. Tightening torque values are calculated from the formula $T = KDP$, where T = tightening torque, lb-in.; K = torque-friction coefficient; D = nominal bolt diameter, in.; and P = bolt clamping load developed by tightening, lb.
2. Clamp load is also known as preload or initial load in tension on bolt. Clamp load (lb) is calculated by arbitrarily assuming usable bolt strength is 75 per cent of bolt proof load (psi) times tensile stress area (sq in.) of threaded section of each bolt size. Higher or lower values of clamp load can be used depending on the application requirements and the judgment of the designer.
3. Tensile strength (min psi) of all Grade 6 and 7 bolts is 133,000. Proof load is 105,000 psi.
4. Tensile strength (min psi) of all Grade 8 bolts is 150,000 psi. Proof load is 120,000 psi.

another. This means the bolt is never in shear as long as clamping load is high. With most plates, calculations will show that joint strength based on pure clamping load equals or even exceeds bolt shear strength.

In Fig. 7, the downward force, F, which would produce shear in the bracket-mounting bolts, is resisted by projecting ledge C. This design approach eliminates the need for bolts fitted into close-tolerance holes. Either studs, cap screws, or bolts can be used.

Under load F, the bracket tends to rotate about point C. The moment of the load, Fx, must equal the sum of the moments of the bolts or $P_B b$ and $P_A a$. For bolts A and B to be equally effective in carrying tension load, $P_B b$ should equal $P_A a$. Bolt A would have to be much larger than bolt B to do this. In most applications it is usually more convenient to select bolts all the same size. With this approach, the bolt at A must be strong enough to withstand the Fx moment. For this reason, bolt A should be located as far from point C as practical. Bolt B serves primarily to assure correct location.

Bending and Tension Loads: In many mechanically fastened joints, such as brake bands, flywheel rims, etc., a bolt cannot be placed directly in line with the applied load. Bolts in such applications are subjected to both bending (flexure) and tensile stresses. The threaded portion of a bolt is particularly weak against bending stress, because cracks are easily started at the root of the threads. Screws used in this manner should be selected with a large factor of safety.

Shock-Loaded Bolts: Under shock loading conditions, bolts or tie rods should be selected not only for strength but also for their ability to absorb impact energy. Assume, for example, a suspended bolt has a weight w, that falls along its shank through a free distance d. When the weight strikes the bolt head, the shank of the bolt yields and is stretched a distance Δd in absorbing the impact energy and bringing the weight to rest. The assumptions made here are that the support, bolt head, and weight do not yield, and that all the live energy is absorbed by the bolt shank. This is not exactly the case, but the bolt obviously is the "yielding" member, relatively, and therefore the deformation of the other parts can be disregarded in most cases.

The total energy absorbed by the bolt within its elastic limit is $W(d + \Delta d)$. In absorbing this energy, the bolt develops a resistance which is maximum when the bolt is elongated distance Δd. If bolt resistance forces are assumed to vary from 0 to F while the bolt is stretched a distance Δd, total internal work developed in the bolt shank is $(\Delta d)\,F/2$. Therefore,

$$W(d + \Delta d) = \frac{(\Delta d)F}{2} = (\Delta d)\,\frac{S_t A}{2}$$

or

$$S_t = \frac{2W}{A}\left(1 + \frac{d}{\Delta d}\right)$$

where S_t = tensile stress in the bolt shank, psi; and A = shank area, sq in. With all other factors equal, the tensile stress S_t becomes smaller when the bolt is more elastic. Though it seems incongruous, in this case the tensile stress S_t goes down as the elongation Δd increases. Elongation can be increased by using a longer bolt or one with a smaller shank.

In shock applications, a bolt should be selected with a shank area approximately equal to the stress area of the threads so the bolt will develop uniform stress throughout undershock loading. Such a bolt will also develop maximum elongation for a given stress and bolt length. Such bolts are known as waisted or necked-down bolts.

High-Strength Fasteners

There is presently a marked trend towards high-strength bolts. Manufactured in heat-treated carbon steel, bolts with tensile strengths of well over 100,000 psi are not uncommon. This classification of fasteners has been standardized as SAE Grade 5, and is also covered in ASTM specification A325. Where strength is an important factor in design, this grade provides the most strength per dollar of fastener cost. Higher strengths are available in alloy steels, but generally at increasing relative cost.

High-strength fasteners offer several design advantages. Fewer fasteners, smaller fasteners, or both, can be used in a particular application, providing lower weight, lower cost, and a more compact design. Weight is saved not only in the fasteners themselves, but also in the assembled parts because of the reduction in size of flanges. There may be an improvement in fastener functioning because smaller fasteners can often be placed near the line of loading, resulting in less eccentric load or bending of the fastener.

The most important advantage of higher fastener strength is that it permits higher clamping force when the fastener is fully tightened.

When a bolted joint is assembled using high strength fasteners, the prime object should be to tighten the bolt to develop as high a preload as is compatible with the service loading condition on the joint. Preload for bolts used in rigid joints may safely approach yield strength of the fastener. Actually, in many instances, bolt tension may be much higher, extending beyond yield and into the plastic range of the material.

The belief that bolts stressed beyond their yield point become plastic and lose all their load carrying ability is not true. The stress-strain curve for an SAE Grade 5 or A325 bolt is a straight line up to the elastic limit, then it curves off gradually without sudden or clearly defined yield point to an ultimate strength 35 per cent greater than minimum yield.

There are two important facts: 1. There is no sudden yield point. 2. This 35 per cent margin is a reserve strength which gives the bolt plenty of additional capacity above minimum yield. Joints with bolts stressed beyond their yield point will perform as well as, or better than, joints with bolts stressed to a lower preload. The joints will carry as much load statically, will probably have greater resistance to fatigue, and the bolts themselves are not weakened due to overtightening.

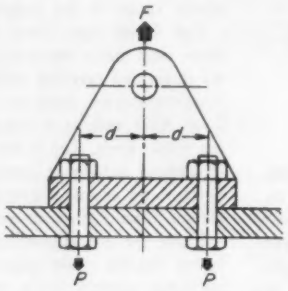
When a bolt is tightened, there is a combined stress compounded of axial tension due to clamping and torsion due to frictional drag on the threads. The bolt may break during tightening due to this combined stress, but at the time of failure the tensile component is only about 80 per cent of the ultimate strength of the bolt. If the bolt is tightened just to the point of failure and the wrench removed, the torsional component quickly disappears, leaving only the axial tensile stress. Thus, when the service loads come onto the joint, some 20 per cent of the bolt strength is still available.

High-tensile bolting very definitely increases the fatigue strength of the other members of the joint; in fact, this increase is so great that it becomes apparent that failure by fatigue need no longer be a major consideration in the design of those members subjected to stress reversal. The fatigue strength of bolted joints for failure at two million cycles will be in excess of 20,000 psi main member stress.

Design Examples

In most joint designs, fasteners are subjected to loads in tension, shear, and bending. For simple tension loading, or simple shear loading, calculations are straightforward and based on simple relationships. When a fastener is subjected to combinations of forces, and the loading is complex, solution requires more sophisticated techniques. Examples illustrating solutions to fastener problems for different conditions of loading appear on the next five pages.

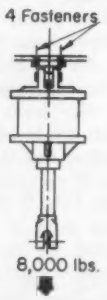
Simple Tension Load



Load is applied through the center of equally spaced fasteners.

Basic Relationships: By summation of forces, $F = Pn$, where F = tension load on joint, lb; P = fastener load in tension, lb; and n = number of fasteners.

Fastener stress, $S_t = P/A_s$; where S_t = fastener stress in tension, psi; P = fastener load in tension, lb; and A_s = tensile stress area, sq in.



Example: An air cylinder mounted to a four-hole bracket develops a pull of 8000 lb. Design choice is between SAE Grade 2 or Grade 5 steel bolts, at a maximum allowable stress of 80 per cent of the minimum proof-load strength values listed in Table 7. Assume joint is rigid, factor of safety is 2, and a 50 per cent impact-load allowance should be used.

Select the proper grade of fastener material and size of bolts to carry the total load on the mounting-bracket.

Total design load on bolts,

$$F = 2[8000 + 8000(0.5)] = 24{,}000 \text{ lb}$$

$$P = \frac{F}{n} = 6000 \text{ lb per bolt}$$

For Grade 2 bolts through ½ in. sizes, the design strength value would be 80 per cent of 55,000 psi, or 44,000 psi. From the nomograph, the line connecting 44,000 on the S scale and 6000 on the P scale passes slightly under the ½ in. coarse-thread bolt size. Either a ½ in. coarse or fine thread bolt could be used. From the nomograph, for a torque coefficient value, K = 0.2, nut-tightening torque should be 50 lb-ft to develop a 6000 lb clamping load on the joint members.

For Grade 5 bolts in sizes through ½ in., proof load strength given by Table 7 is 85,000 psi. Multiplying by 0.8 gives 68,000 psi. For a 6000-lb clamping load, bolt size is ⅜ in. fine thread or 7/16 in. coarse thread. Tightening torque for the 7/16-in. coarse-thread is about 44 lb ft.

Tension Load From Moment

Joint load is carried by two rows of bolts.

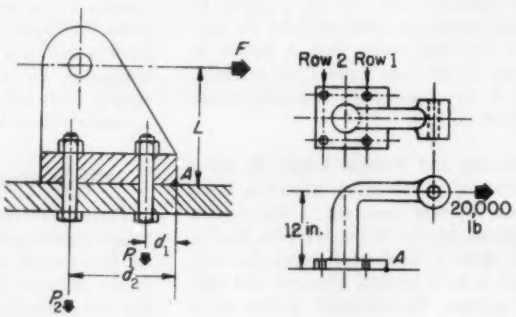
Basic Relationships: By summation of moments, $FL = P_1d_1 + P_2d_2$. If the joint members are rigid, and shear load is taken by dowel pins, the applied tension loads developed are proportional to the distance from fulcrum point A,

$$\frac{P_2}{P_1} = \frac{d_2}{d_1} \text{ or } P_2 = P_1\frac{d_2}{d_1}$$

Therefore,

$$P_1 = \frac{FLd_1}{d_1^2 + d_2^2} \text{ and } P_2 = \frac{FLd_2}{d_1^2 + d_2^2}$$

Bolt material and size should be selected to permit a clamping load (pre-load) value exceeding P_1 and P_2.



Example: A rigid bracket is mounted on a rigid base as shown. All shear loads on the bracket are absorbed by dowel pins (not shown). For the tension members, use Grade 2 bolts with a maximum allowable design stress of 2/3 minimum tensile strength, Table 7, which is 46,000 psi for bolts up to ½ in. in this grade. Based on recommended practice, bolt preload should exceed the applied load. To insure adequate clamping force, a factor of 1.15 will be introduced. In practice, this factor will vary with the application and is determined largely on the basis of judgment and experience.

The applied load, P_1, developed in the first row of bolts is

$$P_1 = \frac{20{,}000(12)(3.5)}{(3.5)^2 + (10.5)^2} = 6857 \text{ lb}$$

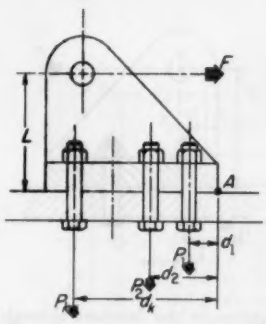
or approximately 3400-lb load in each bolt. Bolt preload then is 3400 (1.15) or approximately 4000 lb in each bolt. With 46,000 psi as the bolt design strength and 4000 lb as the load, the nomograph shows a size requirement of ⅝ in., UNF. Nut-tightening torque for this preload value and K = 0.2 is 25-lb-ft.

The total load, P_2, in the second row of bolts is

$$P_2 = \frac{20{,}000(12)(10.5)}{(3.5)^2 + (10.5)^2} = 20{,}571 \text{ lb}$$

or approximately 10,300-lb load in each bolt. Preload is 10,300 (1.15) or approximately 12,000 lb per bolt. From the nomograph, this requires a ⅝ in., UNF bolt tightened to 125 lb-ft.

Tension Load From Moment

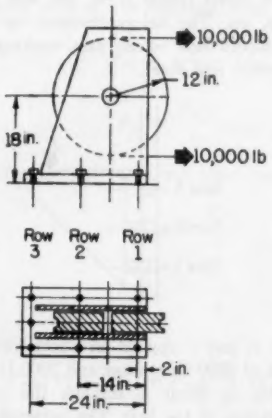


Joint load is carried by k rows of bolts.

Basic Relationships: The general equation for maximum tensile fastener load is:

$$P_k = \frac{FLd_k}{(n_1d_1)^2 + (n_2d_2)^2 + \ldots + (n_kd_k)^2}$$

where n represents number of fasteners in each row. All shear forces are assumed to be carried by dowel pins. Since normally all fasteners are the same size, the most heavily loaded fastener is the one of critical concern.



Example: A sheave support is bolted to a cast-iron base by seven cap screws. Use ½ of the cap screw proof-load strength as working design load. A 20,000 lb load is taken through the center of the sheave axle 18 in. from the base. The shear load is resisted by dowel pins. Determine the maximum load developed in each screw in Row 3 and select a screw size.

$$P_3 = \frac{20{,}000(18)(24)}{2(2^2 + 14^2) + 3(24^2)} = 4060 \text{ lb}$$

which is the load in each screw in Row 3. From Table 6 a logical choice in Grade 2 would be a ½ in. cap screw, with a proof load of 7,800 lb. In Grade 8, a ⅜ in. cap screw with a proof load of 9,300 lb could be selected.

Tension Load on Circular Base

A moment is tending to tip a circular base about a point.

Basic Relationships: By summation of moments about point A, $FL = (P_1/d_1)(d_1^2 + d_2^2 + d_3^2 + \ldots d_6^2)$, where $d_1 = a - b\cos\alpha$, etc.

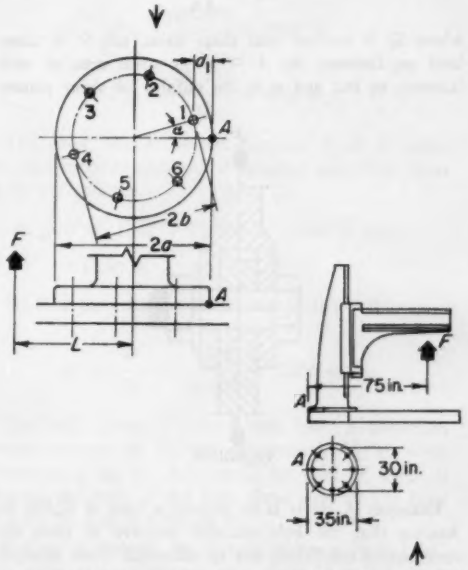
By substituting values of d into the foregoing equation,

$$P_1 = FL\left[\frac{a - b\cos\alpha}{6a^2 + 3b^2}\right]$$

The maximum load in any fastener will occur at a distance $a + b$ from A, or when $\cos\alpha = -1$. This gives the general equation

$$P_{max} = FL\left[\frac{a + b}{na^2 + \dfrac{nb^2}{2}}\right]$$

where n = number of equal size, equally spaced fasteners.



Example: The column of a drill press is fastened with eight bolts to a base plate. A load F of 20,000 lb is applied along a line 75 in. from fulcrum point A. To insure adequate clamping force, multiply actual bolt loads by a factor of 1.25. Bolt strength to be used is 75 per cent of the proof load values listed in Table 7. Determine the size of SAE Grade 5 steel bolts required to anchor the press.

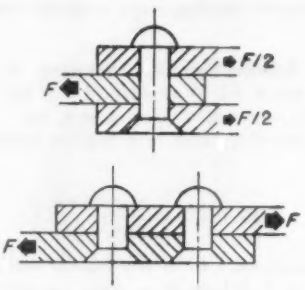
$$P_{max} = 20{,}000(75)\left[\frac{15 + 17.5}{8(225) + 4(306.25)}\right]$$

$$= 16{,}070 \text{ lb}$$

and preload is 16,070(1.25) or approximately 20,000 lb.

For a Grade 5 bolt, 75 per cent of the proof load (which is 85,000 psi through ¾ in. sizes) is approximately 64,000 psi. This bolt material strength on the S scale in the nomograph connected to 20.000 lb on the P scale gives bolt size as ¾ in. UNC thread. Nut-tightening torque for $K = 0.2$ is 250 lb ft. For simplicity, all bolts should be made the same size.

Simple Shear Load

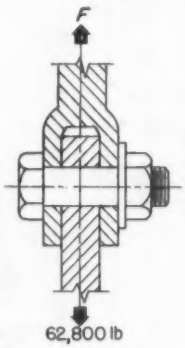


Load is applied to a fastener in one or more shear planes.

Basic Relationships: The general equation for fasteners in shear is

$$S_s = \frac{P}{An}$$

where S_s = average unit shear stress, psi; P = shear load on fastener, lb; A = shear stress area of each fastener, sq in.; and n is the number of shear planes.



Example: A clevis is to support a load of 62,800 lb. Assume that the bolt material required to meet environmental conditions has an allowable shear strength of approximately 50 per cent of the tensile strength for Grade 2 bolts, or S_s = 27,500 psi. Calculate the exact size of the bolt body assuming there are no threads in the shear planes.

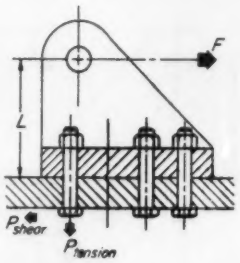
Since there are two shear planes, shear load $P = F/2 = 62{,}800/2 = 31{,}400$ lb.

$$A = \frac{P}{S_s} = \frac{31{,}400}{27{,}500} = 1.14 \text{ sq in.} = \frac{\pi d^2}{4}$$

$$d = \sqrt{\frac{1.14 \times 4}{3.14}} = 1.20 \text{ in}$$

Use a 1¼ in., Grade 2 bolt.

Combined Shear and Tension Load



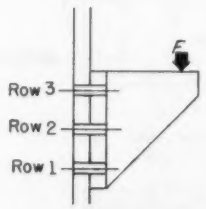
Load is applied to the fasteners through a moment arm.

Basic Relationships: When fasteners are subjected to a combination of tension and shear loads, the maximum intensity of tensile (principal) stress $S_{t,\,max}$ and the maximum intensity of shear stress $S_{s,\,max}$ are

$$S_{t,\,max} = \frac{S_t}{2} + \sqrt{S_s^2 + \frac{S_t^2}{4}}$$

$$S_{s,\,max} = \sqrt{S_s^2 + \frac{S_t^2}{4}}$$

where S_t = direct tensile stress, psi, and S_s = direct shear stress, psi. The values obtained by using these equations should not exceed safe working stresses of bolts in tension and shear.



Example: A load F applied on a seat connection produces loads of 5000 lb tension and 3000 lb shear on a bolt in Row 3. Shear is through the body or unthreaded section of the bolt. The material in a ¾-in. bolt has been found to be safe for an allowable $S_{t,\,max}$ = 20,000 psi and $S_{s,\,max}$ = 11,000 psi. Can the bolt be used in this application?

Area in shear = 0.442 sq in., and area in tension, from Table 2, is 0.334 sq in.

$$S_t = \frac{5000}{0.334} = 15{,}000 \text{ psi}$$

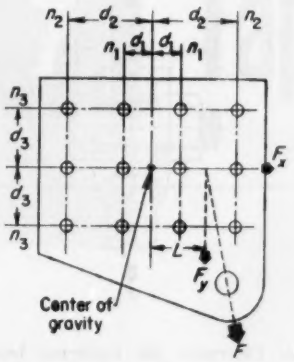
$$S_s = \frac{3000}{0.442} = 6790 \text{ psi}$$

$$S_{t,max} = \frac{15{,}000}{2} + \sqrt{(6790)^2 + \frac{(15{,}000)^2}{4}} = 17{,}600 \text{ psi}$$

$$S_{s,\,max} = \sqrt{(6790)^2 + \frac{(15{,}000)^2}{4}} = 10{,}100 \text{ psi}$$

The bolt can withstand both maximum stress conditions.

Eccentric Shear Load



Load is applied off of center to a group of equal size fasteners.

Basic Relationships: Each fastener resists direct shear equally, and torsional shear by an amount proportional to its radial distance from the center of gravity of the connection. Summation of the moment areas gives:

$$Q = \Sigma x^2 + \Sigma y^2 = 2n_1d_1^2 + 2n_2d_2^2 + 2n_3d_3^2$$

Vector sum of the torsional load is

$$P_{tx} = \frac{F_yL}{Q}\,(d_3)$$

$$P_{ty} = \frac{F_yL}{Q}\,(d_2)$$

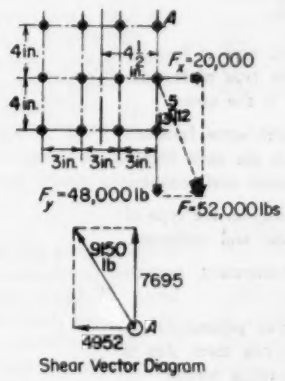
Vector sum of the direct shear load is

$$P_{dx} = \frac{F_x}{n}$$

$$P_{dy} = \frac{F_y}{n}$$

therefore, resultant is

$$P_{max} = \sqrt{(P_{dx} + P_{tx})^2 + (P_{dy} + P_{ty})^2}$$



Shear Vector Diagram

Example: The eccentrically loaded plate shown is pulled with a force of 52,000 lb applied to produce a moment of 48,000 (4.5) = 216,000 lb in. Neglect any resistance to sliding of the plate developed by the clamping effect of the bolts.

Maximum shear strength will be taken as 50 per cent of tensile, or 60,000 psi. Incorporate a safety factor of 2 to give an allowable shear strength, S_s = 30,000 psi.

Determine the maximum shear load developed on any fastener, and select bolt material and size after fastener with the maximum combined shear load is known.

$$Q = [2(3)(1.5)^2 + 2(3)(4.5)^2] + [2(4)(4)^2] = 263$$

$$P_{tx} = \frac{216{,}000(4)}{263} = 3285 \text{ lb}$$

$$P_{ty} = \frac{216{,}000(4.5)}{263} = 3695 \text{ lb}$$

$$P_{dx} = \frac{20{,}000}{12} = 1667 \text{ lb}$$

$$P_{dy} = \frac{48{,}000}{12} = 4000 \text{ lb}$$

The most heavily loaded fastener is at A where the maximum components of torsional and direct shear loads are additive.

$$P_{max} = \sqrt{(1667 + 3285)^2 + (4000 + 3695)^2} = 9150 \text{ lb}$$

To find the required shear area of the bolt,

$$A_s = \frac{P}{S_s} = \frac{9150}{30{,}000} = 0.305 \text{ sq in.}$$

Use SAE Grade 5 bolts which have a minimum tensile strength of 120,000 psi through ¾ in. sizes. Therefore a ⅝ in. bolt could be used if shear is through the body of the bolt. Shear area of the body of a ⅝ in. bolt is 0.307 sq in.

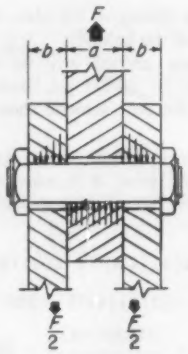
If shear is through the threads, either a ¾-10 UNC bolt with a root-diameter area of 0.302 sq in., or a ¾-16 UNF bolt with a root-diameter area of 0.351 sq in. could be used.

Bolt Clamping to Resist Shear Loading: Bolt size calculations in this example can be simplified by determining total clamping force required to resist the shear loading condition.

Total clamping force $F_t = P_s/\mu$, where P_s = total applied shear load, lb; μ = coefficient of friction between the plate and the member it is bolted to. Using the 52,000-lb load and a 0.2 coefficient of friction, then F_t = 52,000/0.2 = 260,000 lb.

Clamping force which each of the 12 bolts must develop is 260,000/12 or 21,667 lb. For an allowable bolt strength of about 75 per cent of proof load for clamping load, Table 7 shows a Grade 5, ¾-10 UNC bolt would meet the requirement. To develop a clamping force of 22,000 lb, nut-tightening torque, as determined by calculation or from the nomograph, should be 275 lb ft if K = 0.2.

Simple Bending Load



Bending of a fastener may be the design criterion, rather than shear, when oversized holes or spaced joint members are used.

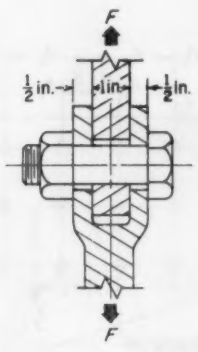
Basic Relationships: Maximum bending moment M is

$$M = \frac{F}{2}\left(\frac{b}{3} + \frac{a}{4}\right)$$

From the flexure formula, $M = S_t\, I/c$ where I = moment of inertia or $\pi d^4/64$ and c = distance to extreme fiber or $d/2$. By substitution,

$$\frac{Fb}{6} + \frac{Fa}{8} = \frac{\pi d^3 S_t}{32}$$

$$F = \frac{3\pi d^3 S_t}{4(3a + 4b)}$$



Example: Determine the maximum bending load that can be safely applied to a 1 in. SAE Grade 2 bolt in the loose-fitting joint shown. There are no threads inside the joint. Allowable tensile fiber stress is 50 per cent of the minimum tensile strength of a Grade 2 bolt, or 27,500 psi. Calculate permissible bending load.

$$F = \frac{3(3.14)\,(1)^3(27{,}500)}{4(3 + 2)} = 12{,}952 \text{ lb}$$

Method of Approach

Each of these examples illustrates a different type of fastener loading condition. However, regardless of the type of fastener application, recommended solution procedure is the same:

1. Calculate fastener load. In a joint where some fasteners bear more load than others, use the value for the most highly loaded fastener, assuming same fastener diameter and material.

2. Select a factor of safety. Base this decision on the type of application, modified by personal experience and judgment.

3. Select a fastener material based on environment, appearance, space limitations, cost factors, etc.

4. Determine fastener size last, after all other parameters are known. In the case of a threaded fastener, one more step is necessary—the determination of fastener tightening torque.

DESIGN DATA

CHAPTER 7

Tapping Screws

TECHNICAL INFORMATION STAFF
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TAPPING screws are designed to tap their own mating threads in holes formed in metals, plastics, and other materials. They can be rapidly assembled since no nut is necessary and access is required from only one side of the joint.

The mating thread created by the tapping screw provides a close fit because no clearance is required as with machine screws assembled in pretapped holes. This close fit keeps the screw tight even under vibration loads.

All tapping screws are manufactured to close tolerances and are case hardened to produce a secure assembly when driven into an untapped hole of the proper size. These screws can be effectively applied in steel, aluminum (cast, extruded, rolled, or die-formed), die castings, cast iron, plastics, glass fibers, asbestos, resin-impregnated plywood, etc.

Tapping-Screw Types

General specifications and dimensional data for standard tapping screws are covered in *American Standard Slotted and Recessed Head Tapping Screws and Metallic Drive Screws*—ASA B18.6.4-1958.

This standard divides tapping screws into two classifications: 1. Thread forming (Types A, B, BP, C and U). 2. Thread cutting (Types D, F, G, T, BF, BG and BT). Recommended design practices for these tapping screws are summarized in Table 1.

Thread-forming tapping screws displace or form the material adjacent to the pilot hole so that it wraps around the screw threads. The mating parts form a perfect fit, with zero tolerance, since no material is removed from the engaged section. Since screw fasteners depend upon friction for a secure joint, the thread-forming screw most nearly attains this ideal with a minimum of tightening torque and, usually, without the addition of lock washers or other locking devices. These types of tapping screws are usually limited to use on sheet metals or the softer materials.

Thread-cutting tapping screws have cutting edges and chip cavities to produce a mating thread by actual removal of material from the engaged section. These are almost always used to join thicker materials, rather than the thread-forming types. The thread-cutting screw requires lower driving torque and keeps the driving effort at a level that can be handled by conventional production-assembly techniques.

There are two main groups of thread-cutting screws based on their thread forms. Types D, F, G, and T have a blunt point with approximate standard machine-screw pitch threads. Types BF, BG, and BT are spaced-thread screws with blunt points and one or more cutting edges and chip cavities.

Types D, F, G, and T are available in both coarse and fine threads. Only coarse threads should be used with weak materials. The fine thread is recommended where it is necessary to have two or more full threads of engagement above the top of the cutting slot and the engaged section is too thin to meet this requirement with coarse threads.

Torque

The most important requirement in the assembly of a tapping screw is that it remain in tension. Driving torque limits should be established so that screws are neither under-tightened nor over-tightened. In critical applications, actual torque-tension tests should be run with torque-measuring equipment.

The torsional strength of low-carbon steel machine screws can vary widely, depending on the heat treatment and material used. But tapping screws are made of selected steels and case-hardened. For these screws, minimum torsional-strength requirements have been established, Table 2. These strengths are well above those for comparable machine screws.

Pilot Holes

To fasten two or more sections together with a tapping screw, a clearance hole slighily larger than the screw diameter must be drilled, clean punched, cast, molded, or extruded in all but the last thickness of material. This last section must have a pilot hole of a specific diameter. Pilot-hole sizes have been established by tapping screw manufacturers through actual laboratory tests. Just any pilot-hole diameter somewhere between the major and minor diameter of the screw is not enough. Recommended hole sizes for standard tapping screws are listed in ASA B18.6.4-1958 and manufacturers' literature.

However, since assembly conditions differ widely, it may be necessary sometimes to deviate from these recommendations. The best way to determine hole size accurately is with a series of tests. In the test piece, drill, punch, or extrude three holes: 1. Recommended (ASA) size. 2. One size larger. 3. One size smaller.

Driving and failure torques for these three hole sizes will show which is best for the particular application. In most cases, the recommended hole size will be suitable. If the material is very hard, a size larger hole may be necessary. A very soft material will usually require a smaller hole.

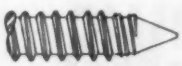
Driving torque required is a function of screw size. Failure torque should be at least three times as great as the driving torque. The margin between the two will take care of torque variations on the assembly line.

Design Details

1. The case-hardened surface on tapping screws must be harder than the

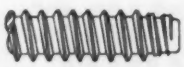
Table 1—Standard Tapping Screws

Thread Forming



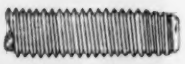
Type A

Spaced thread, gimlet point. Often called sheet-metal screw. Produces strongest joint in light-gage sheet metal. Used in pierced or punched holes where sharp starting point is needed, and exposed point doesn't matter. For sheets up to 20 gage use No. 6 screw, larger screws may be used up to 18 gage. Do not use on thicknesses larger than 18 gage (0.048 in.). Fastest driving of all screw types, except for Type U drive screws. Can be used in easily deformed plastics or metals, with pilot hole less than diameter of screw, to increase joint strength.



Type B

Spaced thread, blunt point. Used for sheet metals thicker than 18 gage. Has slight taper on front end insufficient for self aligning, but when placed in a pilot hole taper holds screw upright making it easy to drive. Drives faster than any screw except Types A and U, with less driving torque than A. Can be used in nonferrous castings, plastics, or soft metals.



Type C

Blunt point screw with threads same pitch as standard machine screw. Used where finer pitch screw is desirable with chip-free assembly. More engaged thread surface increases frictional resistance to loosening. Small helix angle results in back-out torque component under vibration. Obtains higher clamping forces for same applied driving torque.

Type U

Multiple thread, blunt point, metallic drive screw. Threads have high helix angle. Hammered or forced in, this screw has good holding power even when subjected to vibration. Used for permanent fastening, since it is difficult to remove. Do not use in material thinner than one diameter of the screw. Usually does not have a driving slot or recess.

Type BP

Spaced thread. Same as Type B, but has a cone point. Can be used where holes are slightly misaligned.

Thread Cutting

Type D

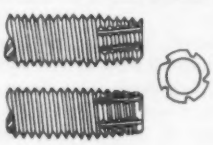
Blunt point screw with a single narrow flute. Approximate machine-screw thread. Used in same manner as Type C where less driving torque is needed. This screw is very good for low-strength metals and plastics; for high-strength, brittle metals such as cast iron; and for rethreading clogged pretapped holes. Easy starting. Gives the highest clamping force for a given torque of any tapping screw.

Type G

Blunt point with single through slot which forms two cutting edges. Approximate machine screw threads, front end having incomplete tapered threads. Recommended for same general usage as Type C but where less driving torque is required. Has higher percentage of thread and longer thread engagement than Type C, making it useful for low-strength metals and plastics.

Type T

Blunt point with single wide flute. Approximate machine screw threads. Usage same as Type D except wide flute provides more chip clearance.

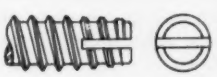


Type F

Approximate machine-screw thread, blunt point. Tapered thread may be complete or incomplete at the producers option. Recommended for same general application conditions as Type C screws but where low driving torque is needed. Because of the five evenly spaced cutting grooves and large chip cavities, this screw is used in a wide range of materials such as aluminum, zinc, die castings, carbon and stainless steel sheet and shapes, cast iron, brass, plastics, etc. Drives faster than a machine screw and resists vibration. Chip space of the flutes is not suitable for deep penetration because of clogging.

Type BF

Spaced thread same as Type B, blunt point, with five evenly spaced cutting grooves and chip cavities. The grooves of this thread remove only a small part of the material to maintain maximum shear strength in the threaded wall of the hole. Wall thickness should be at least 1½ times the major diameter of the screw. Chip room and cutting-groove design are helpful in brittle plastics and die castings to reduce stripping. Used for producing long thread engagement, particularly in blind holes. Permits faster driving than is possible with fine-thread types.



Type BG

Spaced thread, blunt point. Single slot has two cutting edges. Especially useful for brittle or friable material where threads that are too close together will cause material to crumble. Since this screw removes the least amount of material from thread wall, maximum stripping strength is maintained in plastics and soft materials. Can produce long thread engagement, particularly in blind holes. Drives faster than fine threads.

Type BT

Spaced thread, blunt point. Same as Type BG except for single wide flute. Flute provides room for twisted curly chips so that they do not cause binding or reaming of the hole.

engaged material. Otherwise, stripping of the screw threads will occur.

2. Use recommended hole sizes. Tapping screws should always be "driven" into place to develop proper thread action and holding power. Tightening torque, ideally, should be about 2/3 to ¾ of stripping torque. This allows a safety margin for variation of torque output in the driving tool. Ideal driving torque is about ½ of tightening torque.

3. For maximum clamping power in light-gage sheet-metal parts, specify an extruded hole wherever possible. Extruded metal, which projects from the part surface, increases effective thickness for a longer thread engagement. A pierced hole has a similar effect, but to a lesser degree. Clean punched, or drilled holes give least desirable results in such applications.

4. In die castings and plastics, provide a countersink or radius on starting edges of holes. This acts as a guide for starting the screw, strengthens the first thread, and reduces the tendency for chipping or flaking off of this thread.

5. Allow clearance for the pilot section on end of the tapping screw. The tapered points of thread-cutting screws do not have threads that come in contact with the work. Thus, they do not add to holding power. On thin sections, allow the tapping screw to project through the work, but consider possible interference. Don't use these types of screws where flush assembly on the back side is required. In fact, screws flush with the bottom face of thin sections are never practical.

6. For tapered holes, use the mean diameter as a basis for screw selection.

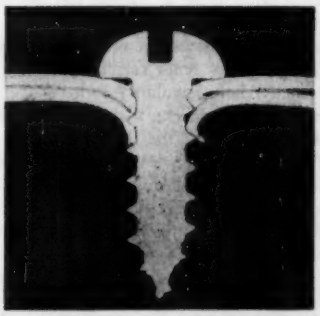
7. For light-gage sheet-metal, study assembly requirements before specifying screws. In parts 24 gage or thinner, there is a tendency to overdrive and strip partial threads near the screw head. For such applications, use fully threaded screws with an undercut at the head to permit expansion of metal in last few threads. Sometimes, a longer screw than necessary for engagement can simplify handling problems in the assembly operation, with a beneficial effect on overall costs.

Table 2—Minimum Torsional Strength for Tapping Screws

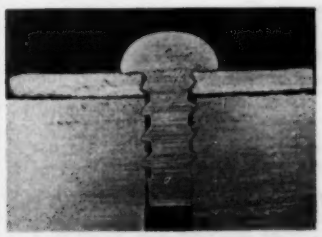
Screw Size	Minimum Torsional Strength (lb-in.) — Thread Forming				Thread Cutting		
	A	B	C Coarse	C Fine	D, F, G, T Coarse	D, F, G, T Fine	BF, BG, BT
2	3	3	5	6	5	6	3
3	8	8	8	9	8	9	8
4	11	12	12	14	12	14	12
5	17	17	17	19	17	19	17
6	20	22	21	25	21	25	22
7	28	28	..	..	..	..	28
8	36	36	39	44	39	44	36
10	45	52	52	69	52	69	52
12	78	82	87	101	87	101	82
14	117	..	..	..	..	..	..
¼	..	133	132	168	132	168	133
16	142	..	..	..	..	..	..
5/16	..	270	285	347	285	347	270
18	183	..	..	..	..	..	..
⅜	..	550	525	664	525	664	550
20	234	..	..	..	..	..	..
24	460	..	..	..	..	..	..

*From referee test given in *American Standard Slotted and Recessed Head Tapping Screws and Metallic Drive Screws—ASA* B18.6.4-1958.

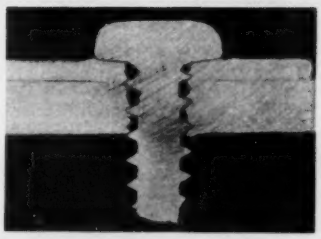
Tapping Screw Application Practices



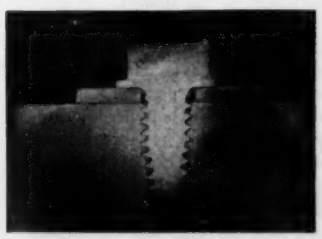
Thread-forming screw with spaced thread assembled in two 0.025 in. thick sheet-metal sections with extruded holes. Drilled or clean punched holes could also be used in such light-gage sheet-metal joints. If possible, nest both sheets together and form holes at the same time to nest burrs and provide a stronger joint.



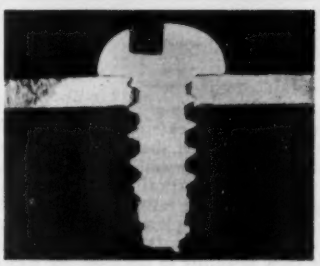
Multiple-thread drive screw driven into cast iron. Although a clearance hole can be used in thin section, stronger joint is obtained by using holes of same size in both sections.



Thread-forming screw with reduced-pitch thread driven into cold-rolled steel section, ⅛ in. thick. Drilled or cleaned punch holes are recommended in heavy-gage sheet metal.



Thread-cutting screw with machine-screw pitch threads driven into cast iron. Clearance hole in part to be fastened is recommended for efficient joint design.



Thread-cutting screw with spaced thread driven into Bakelite part. Countersink or radius is recommended on starting edge of holes in die castings and plastics.

DESIGN DATA

CHAPTER 8

Studs

W. G. WALTERMIRE
Chief Product Engineer, The Lamson & Sessions Co., Cleveland, Ohio

A MORE concentrated effort has been made to eliminate studs than any other fastener. Most passenger car engines have gone from studs to cylinder head bolts. Wheel studs have been largely replaced by wheel bolts. Besides eliminating an assembly operation and either the tapped hole or nut required by a stud, a bolt or cap screw is usually a less expensive fastener.

Still, over-all economy and the need to best fulfill certain design functions require a large use of studs. This is just as true in missiles, atomic reactors, and other late developments as it is in the older, well-established applications. There are many specific reasons:

- Studs act as pilots in assembling and reassembling heavy parts such as turbine casings and cylinder heads.

- On small, lightweight units, the use of studs in automatic machine assembly reduces assembly costs since they permit quick and easy "stack-up" of gaskets or other different parts of a joint. Studs are well adapted to the fast coming era of automation. The difference in thread length between the tap end and nut end of a tap-end stud also permits the stud to be fed automatically to the drivers.

- It is difficult to insure that the axis of a tapped hole is square with the surface of the cover plate or that the bearing surface of a bolt head is perfectly square with its thread axis. When these are not exactly square, a bolt head, being integral with its shank, obviously can give only a small amount with the result that the threads of the screw or bolt are over-stressed on one side. There may even be interference at assembly with the result that clearance holes become egg-shaped in service. The ability of a nut to "float" and adjust itself to the threads on the nut end of a stud is one main reason which impels the choice of studs instead of bolts. The thicker the cover plate, or the longer the tapped hole, the stronger this reason becomes. With a stud and nut, the adjustment permitted by the flexing action of thread engagement in the nut compensates for the inescapable deviations from perfect squareness in the assembly.

- The "runout" of a cap screw or bolt assembled in a hole is doubled as the screw or bolt is turned during assembly. Thus, clearance holes must be sufficiently large to permit the use of these fasteners, and very little misalignment and mislocation of tapped holes and assembly holes can be permitted. Usually, hole angularity is in one direction in a block; that is, all holes are angled in the same direction. Runout of the hole adds to that of the fastener to create interference in assembly and eccentric loading, "pulling" the joint to set up deleterious stresses. Since driving the stud in a tapped hole is the first operation in assembly, use of a stud reduces the need for large hole clearance, and very close hole alignment required by a cap screw or bolt.

- The interference fit of tap-end studs provides a lock against turning and loosening of the stud both during service and during assembly and disassembly of locknuts. The first is particularly important where maintenance of prestress, to protect against fatigue failure, is required.

- With sealant, tap-end studs provide a metal-to-metal seal which prevents leakage of liquids or fluids through holes tapped in porous materials.

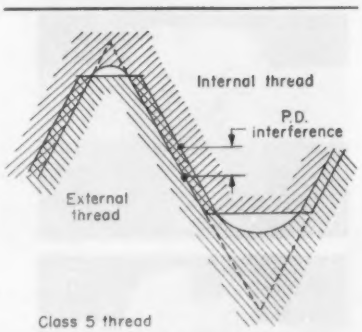


Fig. 1—Class 5 interference-fit thread. Before assembly external thread pitch diameters are larger than mating internal thread. During assembly threads compress and flow, elastically and plastically, to produce holding torques. The threads of the stud flow plastically to increase the major diameter; the threads of the hole flow inwardly to decrease the minor diameter.

Stud Standards

The only standards for studs presently available are those published by the Industrial Fasteners Institute.[1] These standards cover dimensions and proportions, threads, and material details, providing a practical guide for stud specifications.

In brief, the IFI standards set up four basic *classes* of studs, Table 1, dividing each of the first two classes into four *types*:

Type 1, the old "rough" or unfinished stud.
Type 2, optional full or undersized body.
Type 3, full size body only.
Type 4, close-tolerance body.

Class 5 Interference-fit Threads

Before assembly, Class 5 external-thread pitch diameters are larger than those of the mating internal thread. During assembly the threads compress and flow, elastically and plastically to produce holding torques. The threads of the stud flow plastically to increase the major diameter; the threads of the hole flow inwardly to decrease the minor diameter.

The Class 5 interference-fit thread is detailed in ASA Trial Standard B1.12 which has been published in full by the

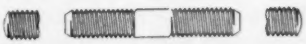
[1]References are tabulated at end of chapter.

Table 1—Classes of Studs

Class 1—Tap-End Studs

Interference-fit thread at tap end. Also known as a gland type stud. Uses Class 5 truncated type thread (ASA Trial Standard B1.12, issued in 1959). This standard is based on assembling a stud in a Class 3 tapped hole and eliminates the old Class 5 thread troubles that so long plagued application of this type of stud.

For replacement studs, where the stud purchaser has no control over hole production, lubrication practices, or the frowned-upon practice of "shouldering" in assembly, it is suggested that, for an indefinite transition period, the use of the old 1950 Supplement to H28-1944, Table 17(a), Class 5 pitch diameter limits[4] be continued, but with the thread moderately truncated. This practice results in trouble-free assembly with "old" holes.



Class 2—Double-End Studs

Has free-running thread at both ends. Also known as a flange stud. May be assembled with two nuts or in a tapped hole with one nut.

IFI Standard provides for the same length of Class 2A, UNC, UNF, or 8UN threads at both ends. If this type of stud is used in a pressure-temperature application in which the 2A allowance cannot be consumed by plating or coating, the PD and OD limits required by the purchaser should always be included as part of the thread designation. Like the Tap-End studs, this class is divided into four types according to the body, or shoulder, dimensions required by a design.

Class 3—Bolt Studs for Pressure-Temperature Piping

Continuous threaded bolt-stud for use in high temperature, high-pressure applications. Conforms to requirements of ASA B16.5. If the 2A allowance cannot be consumed by plating or coating on any stud of this type, the PD and OD limits required by the purchaser should always be included as part of the thread designation.

Unlike other studs and bolts, length of the two points of this class of bolt-stud are *not* included in the stud length.

Class 4—Continuous Thread Studs

General-purpose stud ranging in size from large studs for railroad and mill supply usage to small threaded wires. Latter are often medium-carbon heat-treated or low-carbon case-hardened steel. Case-hardened studs can form their own thread in die-cast and other soft materials.

IFI.[3] Basically this standard is based on the following concepts:

- "Bottoming" or "shouldering" studs is to be discouraged. These practices provide uneven stand-out and set up undesirable radial compressive stresses which often become relieved during service operation, permitting the stud to loosen. Driving to a stop is recommended.

- Stud drive torques are derived from the *pitch-diameter interference, length of thread engagement,* and *depth of thread engagement.* Torques are regulated within the traditional maximum and minimum values, published in former H28 Standards,[4] by:

1. Lubricating the hole in assembling ferrous materials.
2. Tapping holes to Class 3 pitch diameters and using Class 3 pitch diameter tolerances on the studs. Note that the *resultant pitch diameter interference* is the same regardless of material and hardness of the stud and tapped member.
3. Using 1¼ diameters length of engagement for assembling in ferrous material; 2½ diameters *length of engagement* for assembling in nonferrous material.
4. Obtaining the torque control needed to avoid the danger of failing the stud in torsion on the one hand, or of stud loosening on the other, by:

Table 2—Special Locking Studs

Lok Thred

Provides interference at the root diameter only, in contrast to the Class 5 thread with interference on the pitch diameter.

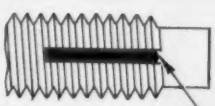
Root of the stud thread is truncated and tapered at a 6 deg angle, producing radial compressive pressures through interference with the minor diameter of the tapped hole.

A controlled root tap is recommended for the hole to produce a rounded root and to eliminate spin-up burrs from tapping. If such a tap is not used, burrs may cause seizing and galling in assembly. As a result of controlled OD, PD and root diameter, this stud offers superior sealing properties as well as a thread lock.

Stud has a 60 per cent thread with the minor diameter tapered rearward from the point in a cork-like manner. Points have tapered lead threads of full design form. Some applications require lubrication of the hole in assembly.

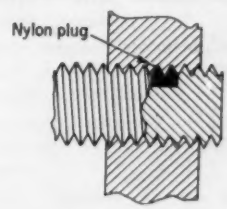
Studs are case hardened, thus preventing movement of the stud thread material during assembly. All movement which takes place during assembly must, therefore, be radially, or nearly radially, outward at the minor diameter of the tapped material. This confines the plastic flow to the material in the tapped assembly, and limits the application of these studs to those materials which can flow readily.

As with any case hardened product, care must be exercised to maintain needed fatigue and shock properties where these are involved.



Long-Lok

Functions similarly to Nylok. Has a section of plastic rod pressed into a longitudinal groove in the threads.



Nylok

Does not involve a metal-to-metal interference, but depends for seal and lock on the action of one or more plugs of nylon material embedded in the fastener.

Provides an excellent lock and seal of proven reusability. Sensitive to sharp edges of tapped holes which have not been countersunk, and to coarse grained material of the tapped hole. Adjustment of the size and protrusion of the nylon plug can correct for this. Limited to temperature 400 F. or lower. Since it is very difficult and expensive to cross drill a hole in a threaded stud or screw of very high hardness, its application is limited in stud materials harder than SAE Grade 8 (150,000 psi ultimate). However, most stud and bolt materials are not this hard.

The length of engagement is normally more than adequate to insure that the stud will fail at full rated strength.

Scweppe Stud

In ductile materials, this case hardened stud forms its own threads. After forming the thread, it provides pitch-interference locking. Limited to relatively soft materials, it requires reasonably good hole preparation to produce adequate thread stripping strength and torque-control, and to insure that the stud assembles square in the hole.

Requires hole sizes longer than those of a regular tapped hole, reducing the thread depth. This will not involve loss of thread shear (stripping) strength if the length of engagement is adequate to compensate for the loss of thread depth.

a. Heavily truncating the major diameter of studs driven in ferrous material of hardness over 160 Brinell and lightly truncating studs going into other materials. Degree of truncation varies according to size.

b. Truncating the minor diameter of tapped holes in ferrous material, but using standard Class 3 minor diameters for holes tapped in nonferrous material.

c. Using the *depth of thread engagement* that results from truncating threads of stud and hole to finally regulate torque. The resultant thread depths are always adequate to prevent cross-threading and to provide full strength. Thread designations are provided in the standard to cover the combinations of truncations.

The research leading to the stud standard was reported in an article published in 1956.[5] Of particular importance were two findings: 1. As stud size increases, torques become particularly affected by length of engagement. 2. Truncating the crests of stud and hole, besides providing torque control, also provides room for flow of displaced metal. It was lack of this room which was generally responsible for the seizing, galling, and loosening often obtained with the old interference-fit threads, no matter how accurately toleranced they were.

Special Studs

Prior to the new Class 5 thread, interference-fit threads were endless, but indispensable, trouble-makers. As a result, several special designs were developed to avoid the trouble and, generally, to provide a seal or other advantage not inherent in a Class 5 thread. Prominent types of special studs are covered in Table 2.

Pitch-interference studs have been made with the "lead," or pitch, of the external thread slightly different from that of the internal thread. These studs lose their holding torque if stud and tapped materials are not exactly the same hardness or if the stud is loaded to more than about half its proof load value.

Other expedients, attempted with varying success, include the use of springs or spring washers in the bottom of a blind tapped hole to engage the points of studs. Various types of captive fasteners, thread inserts, rivet-type bolts, hook-knurl bolts and weld bolts are also often superior replacements for studs. Plastic coated bolts and studs are also available as well as a plastic sealing compound which can be applied at assembly.

References

1. ***Bolt, Nut and Rivet Standards***, Third Edition, Industrial Fasteners Institute, Cleveland, Ohio, 1959, pp. 52-61.
2. 1950 ***Supplement to Screw-Thread Standards for Federal Services*** 1944, Superintendent of Documents, U. S. Gov't Printing Office, Washington, D. C., 1951, Table 17 (a).
3. Reference 1, pp. 200-205.
4. ***Screw-Thread Standards for Federal Services*** 1944, NBS Handbook H28, Superintendent of Documents, U. S. Gov't Printing Office, Washington, D. C., 1945.
5. W. G. Waltermire — "Interference-Fit Thread," MACHINE DESIGN, Sept. 6, 1956, Vol. 28, No. 17, p. 83.

DESIGN DATA

CHAPTER 9

Locknuts

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National Machine Products Co., Utica, Mich.

PRACTICALLY speaking, every nut is a locknut. Degree of locking ability varies widely, but every nut is capable of producing a tight joint under proper conditions of assembly and service.

Unfortunately, for most of the conventional types of nuts, these ideal conditions seldom occur in practice. Vibration, cyclic loading, and special assembly provisions are common problems that often require more than ordinary measures in joint design to achieve a satisfactory solution. To meet these conditions, a number of practical and effective nut designs with special locking features has been developed.

In this chapter, major attention will be devoted to four principal types of nuts which provide such locking features:

1. Jam nuts
2. Castle or slotted nuts
3. Free-spinning locknuts
4. Prevailing-torque locknuts

In addition to these nut forms, several other methods can be used to prevent a conventional nut from working loose under vibration:

- Peening the bolt end which extends through the nut.
- Staking or deforming threads of the nut.
- Using lockwashers of various types.
- Providing special threads on both nut and bolt.
- Doping the mating threads with cement, lacquers, or special sealants.

Use of these methods may be justified by the particular assembly requirements but usually involves extra labor, extra manufacturing operations, or additional parts to buy, stock, and install.

Theoretically, a locking device is not required on a long bolt which is properly tightened, even though the bolt is highly stressed and loaded dynamically. In such instances, elastic elongation is usually sufficient to absorb ordinary losses of tension due to embedding of bolt head or nut bearing face without total loss.

However, this situation is somewhat different where a short fastener is involved. Here, when forces imbed the bearing face of either the bolt head or nut, the fastener is exposed to stress changes that can cause fatigue. Present locknut designs cannot prevent this condition but they can help to combat its effect.

After a bolt is deprived of its correct tension, the stress range of the load will not cause instant failure. A conventional nut without a locking feature may unscrew completely, allowing the assembly to come apart. But a properly designed locknut will maintain its position on the bolt. As a consequence, the life of the fastener, even under severe fatigue stresses, will still be of considerable duration.

Highly stressed bolts and nuts on critical applications, particularly where potential danger to human beings is involved, are always a serious matter. The value of locking devices in such situations is well established.

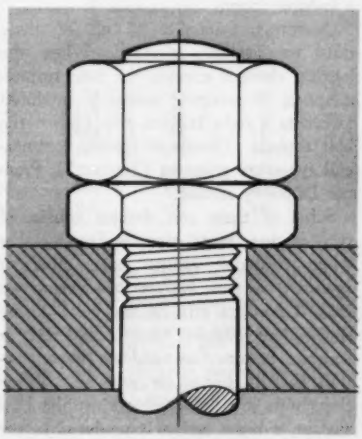

Fig. 1—Recommended practice for assembly of jam nuts to provide a locking action.

As a general guide in joint design, the use of locknuts should be considered when:

- Joint members are subject to vibratory or cyclic motions that might cause loosening.
- Joint members are subject to oscillating tension or torsion loads that might cause loosening.
- Accurate preloading of assembly is difficult because of resilience of parts.
- Joint members are too fragile to withstand preload.
- Added safety factor provided by the addition of a locking feature is desirable because of unknown service conditions.
- Accurate positioning of the nut along a threaded element is required, such as in spacer applications where parts must be free to rotate without end play.

Jam Nuts

A standardized fastener,* the jam nut is a thin nut that should be used under a full nut, Fig. 1, to develop locking action. Both washer-face and double-chamfer nut styles are offered as standard options.

There is some disagreement as to the way in which jam nuts should be assembled. However, based on experience with a wide range of preload conditions, recommended practice is:

1. Torque jam nut to seat only.
2. Assemble full nut on top of jam nut and torque to full preload value while jam nut is held stationary.

This practice produces a reverse tension pressure across the two nuts to develop a prevailing-torque locking condition. The same effect can also be achieved with two full nuts if preload must be developed when the first nut is tightened into position. Also, the same

*American Standard Square and Hexagon Bolts and Nuts—ASA B18.2 1955.

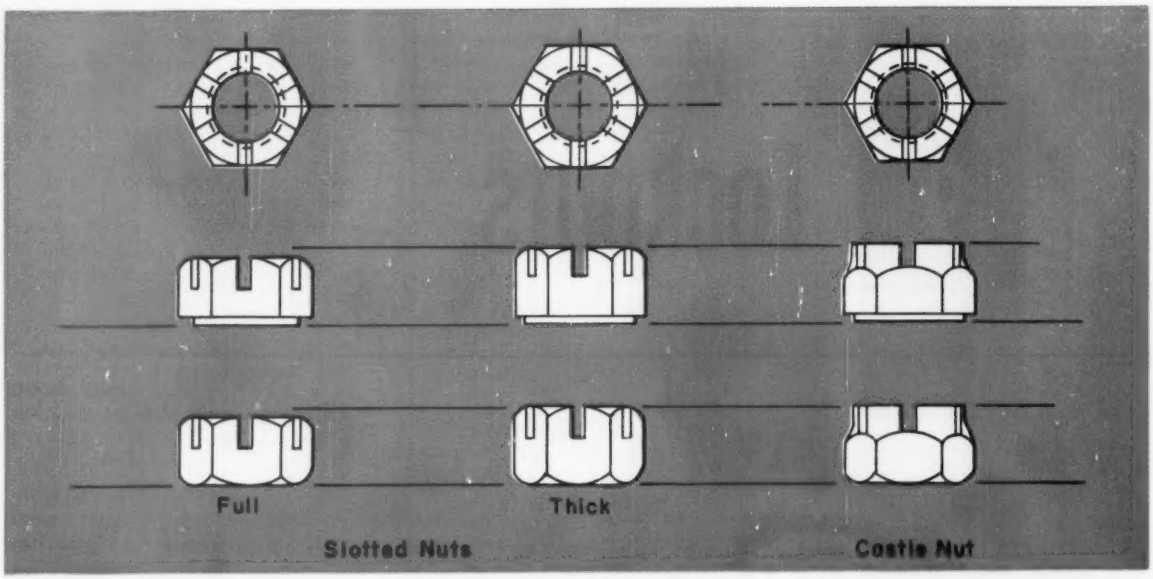

Fig. 2—Standard forms of slotted and castle nuts.

requirement can often be met with a one-piece prevailing-torque locknut with considerable cost advantage in the assembly operation.

As a locking device, the jam nut has limited application. However, there are certain conditions where it is ideal. As a general rule, it is recommended on assemblies where long travel of the nut along the thread under load is required to bring mating parts properly into position. Clamps, brake drums, and certain spring assemblies are typical examples of such requirements. In these applications, use of a prevailing-torque nut is usually not recommended because the long travel of the nut under load can injure the locking feature.

Castle and Slotted Nuts

Both of these standardized nut forms (ASA B18.2-1955), Fig 2, are slotted to receive a cotter pin which passes through a drilled hole in the bolt and serves as the locking member. These nuts are essentially free-spinning locknuts in which the locking feature is added after the preload condition is developed. The castle nut differs principally from the slotted nut in that it has a circular crown of reduced diameter, Fig. 2. When these nuts are specified for an assembly, careful attention should be given to standard dimensions to make sure that the height and across-flats distance fit assembly requirements.

In assembly, these nuts are torqued to preload value, and then nut position is adjusted to line up the slots with the hole in the bolt. This method of assembly introduces a disadvantage on critical preload applications because of the possible alignment variations which may lead to over or under torquing.

As a general rule, the slotted nut is recommended over the castle nut strictly on the basis of availability. Slotted nuts are usually stock items with most manufacturers while castle nuts are generally considered specials.

These nuts are used primarily as safety nuts. From an application standpoint, they are costly to use because of the extra operations involved in their assembly. Unless there is some specific reason for using this type of nut, a one-piece prevailing-torque locknut will often be a better solution on the basis of in-place costs.

Free-Spinning Nuts

A common, but nonstandardized, form of commercial nut, the free-spinning type of locknut is designed to turn freely onto a bolt until seated against a base surface. Further tightening of the nut produces a locking action.

Operating principles of all of these nuts are basically similar. When the locking element engages the base surface, a spring or wedging action is produced to create a tight friction grip against the bolt threads. Details of specific commercial types are given in Chapter 22, Product Directory section.

Some of these nut designs consist of two mating parts that wedge together when tightened against each other or against the part surface to develop an inward pressure grip on the bolt. Other single-piece designs have a recessed or concave bottom face and an upper section that is slotted or grooved. When these nuts are tightened against the base surface, a beam action is produced in the nut, causing the upper threaded section of the nut to bend inward and grip the bolt under pressure. As long as tightening forces are kept within recommended design limits, these nuts will resume their original shape when disassembled and can be readily removed and reused.

In application, these nuts should be seated to the torque values recommended by the manufacturer. These values are usually based on extensive testing to determine optimum torque-tension requirements for effective locking action.

The free-spinning nut is often advantageous where long travel under load is required to seat the nut. As long as the pressure on the nut is not sufficient to develop its locking action, the nut will turn freely into position without danger of damage to the locking feature.

With certain types of free-spinning locknuts, the design of the seating face is such that torquing of the nut to preload produces a brinelling action at the part surface. When these types of nuts are used, specifications should call for the tightening torque to be applied through the bolt or screw head to prevent scoring of the part surface under the nut face.

For all free-spinning locknuts, preloading is essential to develop proper locking action. Except for the two-piece nut designs, in which one nut element serves as the base surface for the other, free-spinning locknuts are not recommended for use on assemblies where there is relative motion between bolted parts or in joints with multiple laminations which may relax bolt tension by embedding or plastic deformation. Use of these nuts should also be avoided with fragile parts that cannot withstand the preloading necessary to develop locking action.

Prevailing-Torque Locknuts

Another common form of commercial

nut, the prevailing-torque type of locknut has a built-in locking feature that develops a full locking action as soon as it is engaged with the bolt threads. These nuts turn freely onto the bolt until the locking feature is engaged and then must be wrenched to final seated position. These nuts will usually retain their locking action on disassembly and can be reused.

Several methods are used in the design of these nuts to develop the prevailing-torque locking action. In one approach, which is perhaps the most common, the top portion of the nut body is preclosed to a noncircular shape to reduce the pitch diameter without changing the angular relationship between mating thread surfaces. When the nut is turned onto the bolt, the preclosed section grips the bolt threads to produce a tight friction clamp. In other designs, the upper portion of the nut is slotted and pressed inward. These locking fingers provide a frictional grip on the bolt thread.

Several nut types use nonmetallic or soft metal plugs, strips, or collars which are retained in the nut. These locking elements are plastically deformed by the bolt threads, producing an interference-fit action to resist rotation on the bolt threads. Another construction has a projecting wire or pin which travels between the bolt threads to provide a ratchet-like locking action. Still other types of nuts use the technique of deflecting a few threads. Locking action is developed by the friction between the deformed nut threads.

These prevailing-torque nuts are perhaps the most versatile types of locknuts in application. Important features and details of the different commercial designs are given in Chapter 22, Product Directory section.

A standard for steel prevailing-torque locknuts has been developed by the Industrial Fasteners Institute and provides a useful guide in checking out nut specifications. This standard outlines a test procedure for determining nut locking ability on a test bolt or special test mandrel. Limiting torque values for different grades of steel prevailing-torque locknuts, as determined from this test, are given in Table 1.

Ideally, prevailing-torque nuts should be used with the minimum thread engagement necessary to develop the holding strength of the nut and the locking action. Torquing of these nuts over a long thread travel under load should be avoided to prevent damage to the locking feature.

Use of unpointed bolts, particularly where the bolt is made of high-alloy material, should be avoided with prevailing-torque nuts. The starting thread on such bolts may damage the prevailing-torque locking feature, thus reducing nut efficiency.

In addition to their suitability as a general-purpose locking device, prevailing-torque locknuts can often be used to advantage as spacer or stop nuts. This function is often required in applications where components must be free to rotate without end play. In assembly, the locknut is tightened down until binding begins to take place and then is backed off just enough to permit free movement. The prevailing-torque locking action holds the nut in position, even under vibration and other conditions of dynamic loading.

General Design

In joint design, the same considerations apply to locknuts as to any other nut. To develop full holding strength, the locknut should be torqued to full preload conditions. On critical preload applications, final torque values should be specified on drawings.

Dimensions of different types of locknuts vary. This point should be kept in mind when locknuts from different manufacturers are being considered for a specific joint application. Bolt lengths, clearance requirements, and other joint details may be affected.

Where increased nut strength is required, consider the possibility of using a thick series nut rather than a heat-treated full nut. The heat-treated nut will usually require a change of bolt chemistry to meet assembly requirements; however, the thick nut will often provide necessary strength without altering the bolt specification. This practice often leads to substantial cost advantages.

Tightening torque values should be established by test. Torque-tension relationships are affected by a number of factors that vary with the conditions of application.

There is only one way to determine whether or not a locknut is suitable for a specific application: Test it under actual assembly conditions. Here is one simple shop procedure that can be used as a check of prevailing-torque type locknuts:

1. From a random sample of the bolts or screws to be used in the actual assembly, pick those with the maximum and minimum pitch diameters.
2. Assemble the locknut being tested to the bolt or screw with maximum pitch diameter and torque to preload condition.
3. Remove nut, assemble it to the minimum pitch diameter thread, and seat to preload requirement.
4. Back off nut on minimum pitch diameter thread and check prevailing-torque locking action.

This test should give a fairly accurate picture of the effectiveness of the nut locking action under normal assembly variations. For a more complete evaluation of the performance of prevailing-torque locknuts, the Industrial Fastener Institute's standardized test procedure mentioned previously is recommended.

Table 1—Locking Ability of Steel Prevailing-Torque Type Locknuts*

Nominal Size	Maximum Prevailing Torque (lb-in.) Grades A and B	Maximum Prevailing Torque (lb-in.) Grades C and D	Minimum Breakaway Torque (lb-in.) 1st removal Grades A and B	Minimum Breakaway Torque (lb-in.) 1st removal Grades C and D	Minimum Breakaway Torque (lb-in.) 5th removal Grades A and B	Minimum Breakaway Torque (lb-in.) 5th removal Grades C and D
¼	30	40	5.0	6.0	3.5	4.5
5/16	60	80	8.0	10.5	5.5	7.5
3/8	80	107	12	16	8.5	11.5
7/16	100	133	17	23	12	16
½	150	200	22	30	15	20
9/16	200	266	30	40	21	28
5/8	300	400	39	52	27	36
¾	400	533	58	78	41	54
7/8	600	800	88	117	62	82
1	800	1070	120	160	84	112
1⅛	900	1200	150	200	105	140
1¼	1000	1333	188	250	132	176
1⅜	1200	1600	220	293	154	205
1½	1350	1800	260	346	182	242

*From *Specifications for Hexagon Locknuts Prevailing-Torque Type Steel*, Locknut Section, Industrial Fasteners Institute, May 28, 1958.

As defined by this specification, "a prevailing torque type locknut is one in which the locking feature is self-contained, resists screwing on and off, and does not depend on bolt load for locking." Steel locknuts of this type are classified under four grades, A, B, C, and D, according to strength and performance characteristics defined by the specification. In addition, it is recommended that the different locknut grades be used with the following bolt-material grades: Locknut Grade A with SAE bolt grades 0, 1, and 2; Grade B with SAE 3, 4, and 5; Grades C and D with SAE 6, 7, and 8.

In the test procedure given in this specification, locking ability is determined on a test bolt or special test mandrels. The *prevailing torque* is the on-torque at first installation measured with no load on the bolt, with the locknut in motion, and with the bolt protruding through the locknut between two and three threads. Reverse torque is then applied to the locknut and the *breakaway torque* is measured at the first and fifth removals. It is the torque required to start the locknut in motion at a point such that bolt protrudes between two and three threads through the locknut. Methods of breakaway torque measurement vary slightly for the bolt and mandrel tests.

DESIGN DATA

CHAPTER 10

Washers

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WASHERS are one of the most common forms of hardware and perform many varied functions in fastener assemblies. They may only be required to span an oversize clearance hole, to give a better bearing for nuts or screw faces, or to distribute loads over a greater area. Often, they serve as locking devices for threaded fasteners. They are also used to maintain a spring-resistance pressure, to guard surfaces against marring, and to provide a seal.

Methods of washer assembly are not governed by any specific rules. However, when the washer is used as a lock or bearing face for the fastener, the usual custom is to locate it under the member that is torqued.

Basic Selection Factors

The most important single factor which keeps a screw from loosening is the tension of the screw itself. This tension causes the threads of the screw and the nut or tapped hole to "jam" together, developing a high frictional resistance to turning. Therefore, theoretically, high screw tension keeps a screw from loosening. But, in actual practice, screws do come loose and lose their tension, for several major reasons:

1. A threaded fastener properly applied in a solid joint and not subject to extreme variances of temperature or vibration usually will remain secure. However, vibration and other service conditions create varying tension loads on a screw. If the screw has been properly preloaded to the levels recommended in Chapter 6, some of these tension loads may be beyond the elastic limit, stretching the screw and causing a loss of tension.

2. Mating screw threads are not perfect fits, and the tension of a tightened bolt may be supported by parts of the threads rather than the whole thread. These areas with a high localized pressure will relieve themselves by cold flow, causing a loss of bolt tension.

3. Soft joints, such as those with gaskets, may lose tension because of compacting of the parts.

4. Tension may also be lost through the breaking down or wearing away of painted surfaces under pressure.

5. "Fishtailing" may cause the screw or nut to turn and loosen.

For most of these problems, the best solution may be one of many washer forms available. Selection of a specific washer is influenced by two basic considerations: 1. What primary function is the washer to perform? 2. Which type of washer is best for the job?

Plain Washers

Plain, or flat, washers, Fig. 1, are used primarily to provide a bearing surface for a nut or screw head, to cover large clearance holes, and to distribute fastener loads over a larger area, particularly on soft materials such as aluminum or wood.

Two types of washers are covered in *American Standard Plain Washer* (ASA B27.2-1958) for general use. Type A is a series of steel washers with broad tolerances, where refinement of design is not important. They range from 5/64 to 3⅛ in. hole size and from 3/16 to 5½ in. OD. A Type A washer will probably suffice for rough assemblies.

Type B washers are of higher quality and are specified in narrow, regular and wide diameters for each screw size from No. 0 to 3 in.

ASA B27.2 gives washer hole and outside dimensions. Select a washer with a hole size which allows clearance for the bolt. The outside diameter need not be much more than the across-corners dimension of the nut or screw if the washer is to be used only to provide a bearing face. However, if the purpose of the washer is to span a large clearance hole or to distribute the load over an area of low-strength material, select a thicker washer with a larger OD.

Soft-steel washers are the most common, although washers can be procured of stainless steel, brass, bronze, aluminum or any other metal produced in sheets. Hardened-steel washers are often used under high-tensile bolts.

Conical Washers

Used as spring take-up devices to compensate, in part, for any stretch or other relaxation of the tension in a bolt, cone washers, Fig. 2, are usually made of hardened spring steel. They are generally designed slightly beyond their elastic limit, so the free height before usage is slightly higher than the free height after an application. The difference in height, or set, should be held to a minimum. Excessive

Fig. 1—Plain washer.

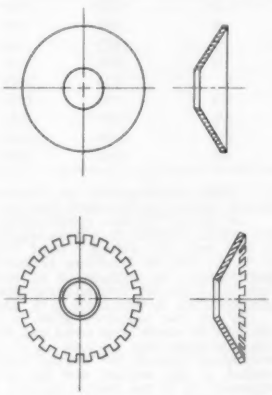


Fig. 2—Cone washers.

cone heights do not add materially to the spring action, and the resulting set may develop internal strains that cause washer failure.

Each combination of hole, outside diameter and material thickness has a definite maximum cone height beyond which the elastic limit of the steel will be exceeded on flattening. The angle of the cone to the base of the washer usually is about 6 deg, and each 0.010 in. of rim width gives approximately 0.001 in. deflection. Variations in spring reactance are obtained by varying material thickness. A good value for designing the load to be supported in the flat position is 50 per cent of the tensile strength of the bolt.

"Belleville" washers is a name often erroneously applied to all cone washers. The true Belleville washer is a spring of conical form made of such materials as heat-treated spring steel. It is designed to operate as a spring by deflecting between the cone and flat positions, and when flatened does not lose height because of set caused by exceding the elastic limit. These springs can be used in multiples by combining them back-to-back (series) to increase the amount of spring movement, or stacked (parallel) to increase the spring reactance.

Cone washers do not have any locking features other than friction, and, in the flattened position, are equivalent to any flat washer as far as locking action is concerned. When the tension in the screw relaxes and the washer tends to assume cone shape, there is less frictional area between the base of the cone and the part surface because the washer is resting on its rim. The frictional area at the nut or screw head is similarly reduced.

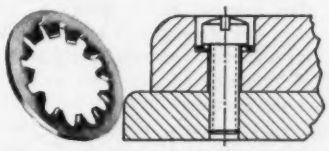
Cone washers are available with teeth on the lower edge, Fig. 2, but these teeth do not add to the security of the bolt. However, they do penetrate the work surface and resist any lateral shifting, particularly on sheet metal.

Helical Spring Lock Washers

Helical spring washers are made of slightly trapezoidal wire formed into a helix of one coil so that the free height is approximately twice the thickness of the washer section, Fig. 3. They are usually made of hardened carbon steel, but also can be made of bronze, stainless steel, K monel, and other resilient materials.

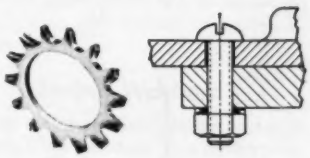
Fig. 3—Helical spring lock washers.

Table 1—Tooth Lock Washers



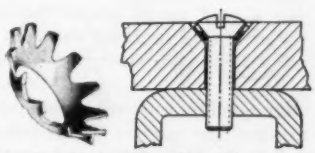
Internal

Used where projection of teeth beyond screw head or nut is objectionable. Presents a finished appearance, similar to plain washer. Standard sizes from No. 2 to 1¼ in. Up to 2⅜ in. available. Heavy washer made in ¼ in. to ⅜ in. sizes.



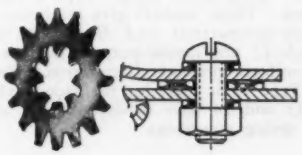
External

Most commonly used where security of assembly is critical. Teeth bite into standard screw heads and nuts to lock. Standard sizes from No. 3 to 1 in. Up to 2¼ in. available.



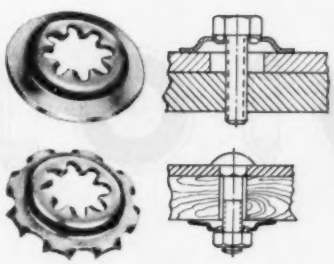
Countersunk

Used under countersunk screw heads. Standard sizes from No. 2 to ½ in. for 82 and 100 deg head styles.



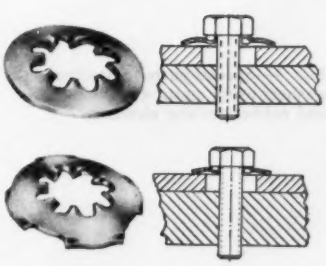
External-Internal

Cover oversize holes. Often used against soft materials and thin sheet steel because of large bearing surface. Can be used between two members which require adjustment before tightening. Resist rotation and sliding movements in final assembly. Can also be used for electrical bonding since teeth penetrate metal coatings to provide ground. Standard sizes from No. 4 to ⅝ in.



Dome Type

Used to put pressure away from hole on workpiece. Recommended for use on soft or thin materials. Also suitable for use over large or elongated clearance holes. Plain-periphery type will not mar workpiece. Tooth-periphery type bites into workpiece and prohibits shifting. Standard sizes from No. 10 to ⅝ in.



Dished Type

Used to put pressure away from hole on workpiece. Covers large bearing surface. Recommended for same general applications as dome type but where resilience rather than rigidity is required. Standard sizes from No. 4 to ½ in.

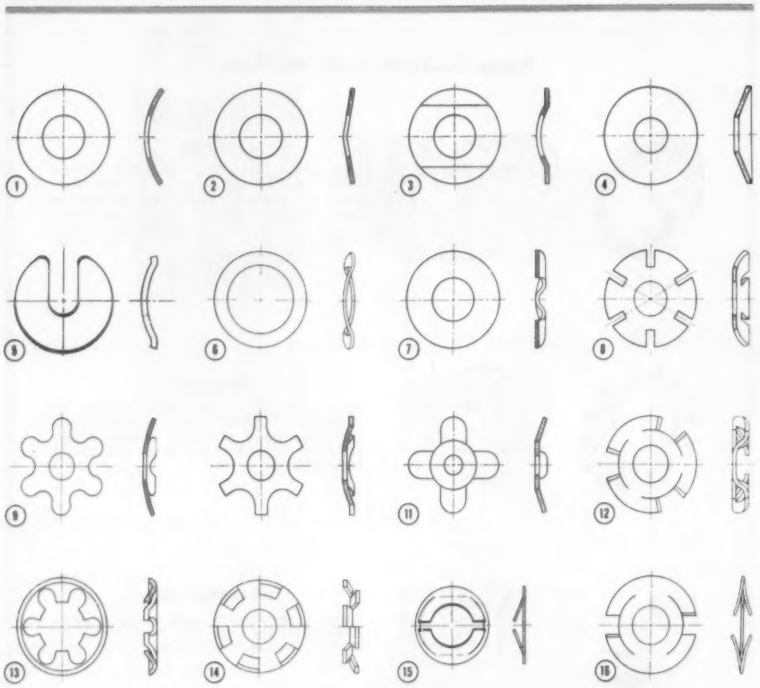


Fig. 4—Typical spring-washer designs. Type 1 is the basic design and most commonly used. It and Type 2 give greatest deflection, have smallest load-bearing surfaces. Type 3 gives less deflection but has greater load-bearing surface on one face. Type 4 is conical and gives still less deflection but stronger spring action. Type 5 slides into place in assembly. Types 6 and 7 have wave form. Type 6 has three waves, Type 7 four or more depending on size. These washers give minimum spring movement with high spring force and permit symmetrical load distribution because of multiple bearing points. Types 8 through 11 are special-purpose designs which provide for greater spring movement with uniform pressure distribution. Types 12 through 16 are also special-purpose types. Type 12 is used for preloaded ball bearings, primarily on electric motors. Types 13 and 14 have modified tooth arrangements, and Types 15 and 16 give maximum spring movement.

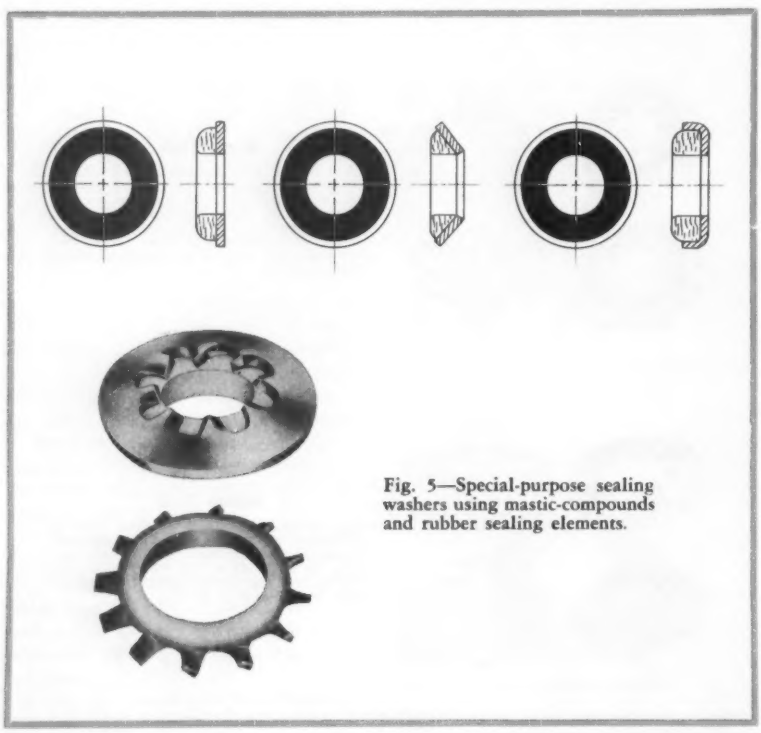


Fig. 5—Special-purpose sealing washers using mastic-compounds and rubber sealing elements.

They are tabulated in *American Standard Lock Washers* (ASA B27.1-1958) as light, medium, heavy, and extra-heavy types for screw sizes from No. 2 to 3 in. inclusive. As defined in this standard, functions of helical spring washers are: 1. Spring take-up devices to compensate for developed looseness and loss of tension between component parts of an assembly. 2. Hardened thrust bearings to facilitate assembly and disassembly of bolted fastenings by decreasing the frictional resistance between the bolted surface and the bearing face of the bolt head or nut.

Effectiveness of these washers in performing the spring take-up function has been questioned by certain authorities. Some feel that their usefulness is limited to the second function, as hardened thrust bearings. However, questions on the suitability of these washers for specific assemblies can be easily resolved by testing under actual service conditions.

The Type 1 helical spring washer is the most commonly used. The spring reactance of this washer comes into play when the tension in the bolt is reduced to a value equal to the force required to flatten the washer. At this point the tension in the bolt is maintained by the expansion of the washer. In the flattened state, this washer becomes equivalent to a hardened plain washer of small OD. Because of the relatively small washer diameter, it is not recommended for use on soft materials or with oversize or elongated clearance holes. Special washers with wider cross sections for increased frictional area are available.

The barbed type or Type 2 helical spring washer, Fig. 3, has turned-up ends which bite into the work piece and nut or screw head. This locking action keeps the bolt from starting to loosen. The turned-up ends, because of their short length and relatively large cross section, are quite rigid, and tend to produce a gouging or milling action on the fastener bearing face. This may or may not be objectionable, depending on the application. The thickness of the washer over the ends is greater than the body, and when the washer is flattened there is a cocking of the nut on the bolt.

Tooth Lock Washers

Made of hardened carbon steel, tooth lock washers have teeth that are twisted or bent out of the planes of the washer faces so that sharp cutting edges are presented to both the workpiece and the bearing face of the screw head or nut. When compressed in position, most of the pressure is supported by the rim of the washer. However, any relaxing of the tension in the screw allows the teeth to bite into the workpiece and the face of the fastener, resisting relative motion. On hex-head screws or nuts where the teeth extend slightly beyond the hex, additional locking occurs on the edges.

Each washer tooth acts as a spring of rather strong reaction because of its short

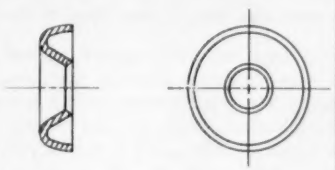


Fig. 6—Finishing washer.

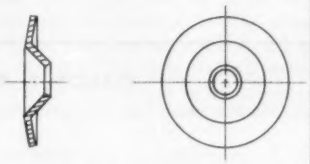


Fig. 7—Fairing washer.

length. The first time they are used, the teeth do not return to their original height, but they exert enough spring reactance in subsequent applications to be used many times. The teeth may produce a slight milling action on the nut or work piece. This usually is not objectionable except on soft materials.

Standard washers of internal, external, countersunk and internal-external tooth design are tabulated in *American Standard Lock Washers* (ASA B27.1-1950) which states: "They serve to lock fasteners, such as bolts and nuts, to the component parts of an assembly, or increase the friction between the fasteners and the assembly." In addition to the standard washers, Table 1, there are many special designs of tooth washers. These include a pyramidal type for heavy duty service; left-hand twisted teeth; right and left-hand twisted teeth combined; special holes such as square, D, or with keys; and washers of special dimensions.

Spring Washers

There are no standard designs for spring washers. They are made in a great variety of sizes and shapes, Fig. 4, and are usually selected from a manufacturers' catalog for some specific purpose. Except for the cone shape, they usually do not have a high value of spring reactance but can be designed to have greater distance of spring action.

Spring washers are often used to produce a predetermined pressure on adjacent members where sliding action is desired, or to serve as spring take-up devices in an assembly where side play is objectionable. They also are used with bearings of a revolving shaft to control end pressure and to eliminate end play.

Spring washers are generally made of spring steel but spring bronze or any other resilient material could also be employed.

Special Purpose Washers

Molded or stamped nonmetallic washers are available in many materials and may be used as seals, electrical insulators, or for protection of the surface of assembled parts.

Many plain, cone, and tooth washers are available, Fig. 5, with special mastic sealing compounds firmly attached to the washer. These washers are used for sealing and vibration isolation in high-production industries.

The finishing washer is typified by the one shown in Fig. 6 which is designed for use with an oval screw head. It eliminates countersunk holes. Finishing washers are used extensively for attaching fabric coverings, since the outer rim grips the material at a point away from the hole.

The fairing washer, Fig 7, is an aircraft development used with flat-head screws on aluminum skins. Since holding pressure is spread over a large area, localized strains around the screws are eliminated. The shape of this washer allows flush surfaces.

DESIGN DATA

CHAPTER 11

Set-Screws

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SET SCREWS are used as semipermanent fasteners to hold a collar, sheave, or gear on a shaft against rotational or translational forces. In contrast to most fastening devices, the set screw is essentially a compression device. Forces developed by the screw point on tightening produce a strong clamping action that resists relative motion between assembled parts. The basic problem in set-screw selection is to find the best combination of set-screw form, size, and point style that will provide the required holding power.

Set screws can be categorized in two ways, by their forms, and by the point style desired. Each of the standardized set-screw forms in Table 1 (ASA B18.62-1956 and ASA B18.3-1954) is available in any one of six point styles. Selection of a specific form or point is influenced by functional, as well as other considerations.

The selection of the type of driver and, thus, the set-screw form will normally be determined by factors other than tightening. Despite higher tightenability, the square head has a major disadvantage; it protrudes. Factors of compactness, weight-saving, safety, and appearance may dictate the use of flush-seating socket or slotted-headless forms.

Size Selection

The most important consideration in size selection is the holding power of set screws. In a typical shaft and collar assembly, Fig. 1, force F developed by the cup-faced point on the shaft due to tightening produces an equal reaction force, F_1. This clamping action results in two frictional forces: One between the shaft and collar, F_2, and another between the shaft and point. These forces provide most of the resistance to relative axial or rotational movement of the parts.

Some additional resistance is contributed by point penetration. Cup-point and cone-point set screws are used without a spotting hole. In these cases, they penetrate the shaft more than oval-point or flat-point set screws due to their smaller face area.

Total static holding power of the cup-point set screw in Fig. 1 is a function of the two friction forces and the point penetration resistance, and can be expressed as a single effective force acting tangentially at the surface of the shaft. The magnitude of this single force also equals the axial holding power of the set-screw, or the resistance of the assembly to relative movement along the longitudinal axis of the shaft. Torsional holding power is determined by multiplying the axial (tangential) holding power by the shaft radius. Holding power is generally specified as the tangential force in pounds, since design considerations may cause different sizes of shaft to be used with a particular size of set screw.

Conventional approach to set-screw selection is usually based on a rule-of-thumb procedure: Set-screw diameter should be roughly equal to one-half the shaft diameter. This rule of thumb often gives satisfactory results, but its range of usefulness is limited. Table 2 has been developed from experimental data as a guide to more scientific size selection. The numbers shown in bold face in Table 2 indicate holding powers of set-screw sizes selected by the rule-of-thumb method.

The holding powers as given are ultimate strengths and should be coupled with specific safety factors appropriate to the given application and load conditions. Good results have been obtained with a safety factor of 1.5 to 2.0 under static load conditions and 4.0 to 8.0 under various dynamic situations.

Although Table 2 was developed for a specific set-screw form and point style, these values can be modified by percentage factors to yield suitable design data for almost any other form and point style. An

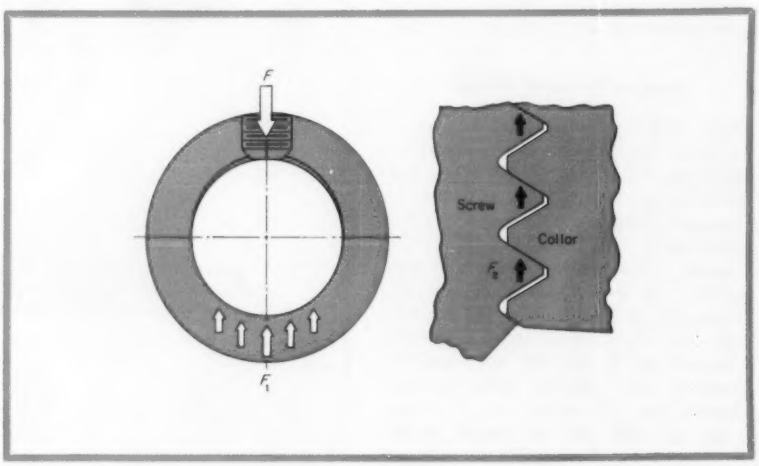


Fig. 1—Shaft and collar assembly shows forces developed in typical set-screw installation.

analysis of the considerations involved is presented here to aid in selecting the optimum set-screw size for any requirement.

Seating Torque: Extensive tests have shown that torsional holding power is almost directly proportional to the seating torque of cup, flat, and oval-point set screws. A typical plot of this characteristic is shown in Fig. 2. Hence, within the strength limits of the assembly, an increase of 50 per cent in the seating torque will increase the holding power by 50 per cent. For example, the torsional holding power of a ½-in. diameter set screw seated at 310 lb-in. on a 1-in. shaft, Table 2, would be 750 lb-in., or one-half of the tabulated value.

Point Style: The set-screw point, by its penetration, can contribute as much as 15 per cent to the total holding power. When the cone-point set screw is used without a spotting hole, or predrilled hole in the shaft, it gives the greatest increase in holding power for a given installation torque because of its deeper penetration. The oval point, which has the least contact area, gives the smallest increase.

If the index for the cup point is taken as 1, the holding power values from Table 2 should be multiplied by 1.07 for cone points, 0.92 for flat or dog points, and 0.90 for oval points. These values assume that the point of the screw is not specially recessed into the shaft and that the penetration is the sole result of tightening. A dog point, for example, seated in a hole drilled in shaft, is actually acting as a pin, and the holding power must be determined by the shear strength of the screw material.

Relative Hardness: Hardness seems to become a significant factor in set-screw selection when there is less than 10 Rockwell C-scale points difference between set-screw point and shafting. As indicated in the typical plot, Fig. 3, there is a slight, gradual decrease in holding power (about 6 per cent) with increasing shaft hardness up to 10 Rockwell points below the hardness of the screw (Rockwell C 50). Then a loss of about 15 per cent of holding power is experienced. This 15 per cent loss represents primarily the amount of holding power contributed by penetration of the point. Hence, since the hardness affects the ability of the set screw to penetrate, this loss of holding power is actually a function of the lack of point penetration.

Fig. 3 is based on a relatively hard, Rockwell C 50 screw point, but the 10-Rockwell point differential can be applied generally. Thus, for a screw hardness of Rockwell C 45, a 15 to 20 per cent loss in holding power should be expected if the shaft hardness is Rockwell C 35 or greater.

Flatted Shafting: Only about 6 per cent more torsional holding power can be expected when screw seats on flat surface. flatting does little to prevent the 0.01-in. relative movement elected as a criterion of failure. Axial holding power is the same.

Length of Thread Engagement: The length of thread engagement has no noticeable effect on axial and torsional holding power, provided there is sufficient engagement to prevent thread stripping in tightening. The length of engagement depends upon such factors as the amount of applied load, type of material, type of thread, and screw diameter. In general, the minimum length of engagement recommended is the diameter of the set screw. This usually permits the development of the recommended seating torque without danger of thread stripping. The tabulated values for seating torque were developed with the assumption that the engagement length was long enough to prevent stripping.

Thread Type: The values tabulated in Table 2 apply to either thread type, since

Table 1—Set Screw Types

Standard Forms

HEXAGON SOCKET

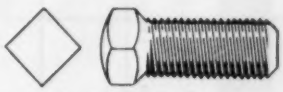
Standard size range: No. 5 to 2 in., threaded entire length of screw in 1/16-in. increments from ¼ to ⅝ in., ⅛-in. increments from ⅝ to 1 in., ¼-in. increments from 1 to 4 in., and ½-in. increments from 4 to 6 in. Coarse or fine-thread series, Class 3A.

FLUTED SOCKET

Same as hexagon socket. Nos. 0, 1, 2, 3, 5, 6 have four flutes, Nos. 4, 8, and larger have six flutes.

SLOTTED HEADLESS

Standard size range: No. 5 to ¾ in., threaded entire length of screw. Coarse or fine-thread series, Class 2A.



SQUARE HEAD

Standard size range: No. 10 to 1½ in. Entire length of body is threaded. Coarse, fine, or 8-threaded series, Class 2A. Sizes ¼ in. and larger are normally available in coarse threads only.

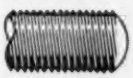
Standard Points

CUP

By far the most widely used. For quick, permanent location of gears, collars, and pulleys on shafts, when cutting-in action of point is not objectionable. Heat-treated screws of Rockwell C 45 hardness or greater can be used on shafts with surface hardness up to Rockwell C 35 without deforming the point.

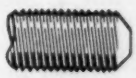
CONE

Used where permanent location of parts is required. Because of penetration, it develops greatest axial and torsional holding power. Where it bears against material of Rockwell C 15 hardness or greater, usually spotted in a hole to half its length, so that penetration is deep enough to develop ample shear strength across cone section.



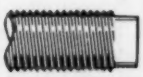
OVAL

Used when frequent adjustment is necessary without excessive deformation of part against which it bears. Also used for seating against angular surfaces. Circular U-grooves or axial V-grooves are sometimes provided in the shaft to allow rotational or longitudinal adjustment. In other applications, shaft is spotted to receive the point. However, has the lowest axial or torsional holding power.



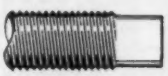
FLAT

Used when frequent resetting of one machine part in relation to another is required. Flat points cause little damage to the part against which the point bears, so are particularly suited for use against hardened steel shafts. Can also be used as adjusting screws for fine linear adjustments. Here, a flat is usually ground on the shaft for better point contact. Also preferred where walls are thin or threaded member is a soft metal.



HALF DOG

The half dog has more threads per length of screw than full dog. More widely used. Normally applied where permanent location of one part in relation to another is desired, spotted in a hole drilled in the shaft. Drilled hole must match the point diameter to prevent side play, holding power is shear strength of point. Occasionally used in place of dowels, and where end of thread must be protected. Recommended for use with hardened members and on hollow tubing, provided some locking device holds screw in place.



FULL DOG

Same as half dog except for a longer point.

Table 2—Selection Data for Cup-Point Set Screws

Nominal Screw Size	Seating Torque (lb-in.)	Axial Holding Power (lb)	Torsional Holding Power (lb-in.) for shaft diameter (in.) of																								
			1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1	1 1/4	1 1/2	1 3/4	2	2 1/2	3	3 1/2	4
No. 0	0.5	50	1.5	2.3	3.1	3.9	4.7	5.4	6.2												
No. 1	1.5	65	2.0	3.0	4.0	5.0	6.1	7.1	8.1	10.0											
No. 2	1.5	85	2.6	4.0	5.3	6.6	8.0	9.3	10.6	13.2	16.0										
No. 3	5	120	3.2	5.6	7.5	9.3	11.3	13.0	15.0	18.7	22.5	26.3									
No. 4	5	160		7.5	10.0	12.5	15.0	17.5	20.0	25.0	30.0	35.0	40.0								
No. 5	9	200			12.5	15.6	18.7	21.8	25.0	31.2	37.5	43.7	50.0	56.2	62						
No. 6	9	250				19	23	27	31	39	47	55	62	70	78	94	109				
No. 8	20	385				30	36	42	48	60	72	84	96	108	120	144	168	192			
No. 10	33	540					51	59	68	84	101	118	135	152	169	202	236	270	338								
¼ in.	87	1000							125	156	187	218	250	281	312	375	437	500	625	750							
5/16 in.	165	1500								234	280	327	375	421	468	562	656	750	937	1125	1310	1500					
⅜ in.	290	2000									375	437	500	562	625	750	875	1000	1250	1500	1750	2000					
7/16 in.	430	2500										545	625	702	780	937	1095	1250	1560	1875	2210	2500	3125				
½ in.	620	3000											750	843	937	1125	1310	1500	1875	2250	2620	3000	3750	4500			
9/16 in.	620	3500												985	1090	1310	1530	1750	2190	2620	3030	3500	4370	5250	6120		
⅝ in.	1225	4000													1250	1500	1750	2000	2500	3000	3500	4000	5000	6000	7000	8000	
¾ in.	2125	5000															1875	2500	3125	3750	4375	5000	6250	7500	8750	10000	
⅞ in.	5000	6000																3000	3750	4500	5250	6000	7500	9000	10500	12000	
1 in.	7000	7000																3500	4375	5250	6120	7000	8750	10500	12250	14000	

Note: Experimental data were obtained by seating an alloy-steel, cup-point set screw against a steel shaft with a hardness of Rockwell C 15. Screw threads were Class 3A, tapped holes were Class 2B. Holding power was defined as the minimum load necessary to produce 0.01 in. of relative movement between the shaft and the collar.

experimental work indicates that a negative difference exists in the performance of coarse and fine threads of the same class of fit.

Type of Driver: The values tabulated in Table 2 are for socket-type set screws. However, they apply equally well to slotted and square-head set screws provided the indicated seating torque is developed. The shape of the driver itself has no direct bearing on the holding power. However, the shape of the driver does have an effect on the seating torque which can be attained.

For the slotted set screw, the maximum seating torque is that which can be developed by a screw driver. Deformation of the screw slot occurs at a torque value much less than the torque which would strip the screw threads.

The maximum torque which can be applied to socket or fluted head set-screws is also lower than that which would strip the screw threads. Hence, the torque which can be applied is a function of the driver. For example, a 5/16-in. socket set screw used in these tests, and seated to its recommended torque of 165 lb-in. developed a torsional holding power of 562 lb-in. on a ¾-in. diameter shaft. The same size slotted set screw can only be tightened to 75 lb-in. on the average. Holding power of this set-screw was 45 per cent less.

Square-head set-screws can be tightened with a wrench until the threads strip or the screw fails in torsional shear. Table 3 lists typical recommended installation torques for square-head set screws.

Number of Set Screws: Two set screws give more holding power than one, but not necessarily twice as much. The tabulated torsional and/or axial holding powers, Table 2, can be multiplied by from 1.30 to 2.00, depending on the angle between the two screws. The holding power is approximately doubled when the second screw is installed in an axial line with the first, but is only about 30 per cent greater when the screws are diametrically opposed. The plot, Fig. 4, shows how much to compensate for any angle in between. Where design dictates that the two screws both be installed on the same circumferential line, an optimum displacement of 60 deg is recommended as the best compromise between maximum holding power and minimum metal between tapped holes. This displacement gives 1.75 times the holding power of one screw alone.

Plating: An increase of 5 to 10 per cent in the holding power for the same tightening torque can be anticipated when the screw is plated with a soft plating such as cadmium or zinc. The plating acts as a lubricant, and less of the applied tightening energy is dissipated in friction at the mating threads. A comparable increase can be achieved by plating the female tapped member, or by using a suitable thread lubricant.

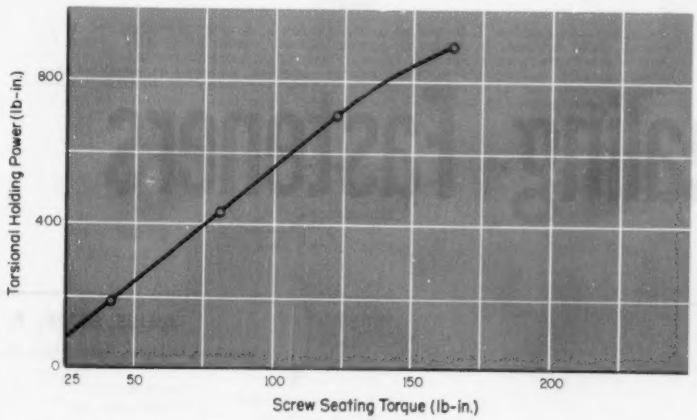


Fig. 2—Torsional holding-power is almost directly proportional to seating torque. Set screw used to obtain plot was 5/16-in. knurled cup-point type seated on 1-in. diameter shaft with hardness Rockwell C 15.

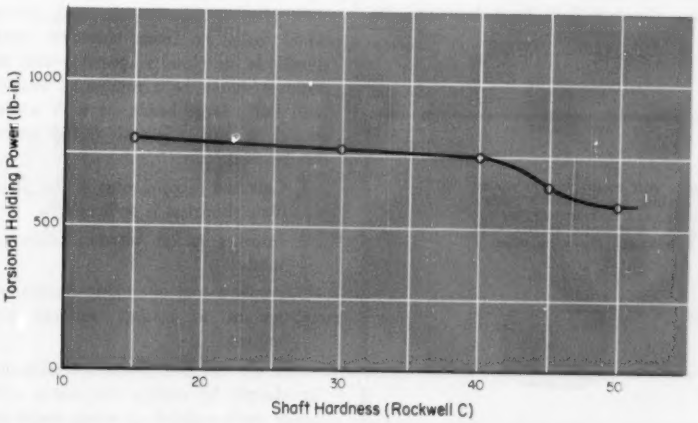


Fig. 3—Considerable loss in holding power is experienced when the difference in hardness between shaft and screw is less than 10 Rockwell C points. Set screw used to obtain plot was 5/16-in. knurled cup-point type seated with 165 lb-in. against 1-in. diameter shaft with hardness Rockwell C 50.

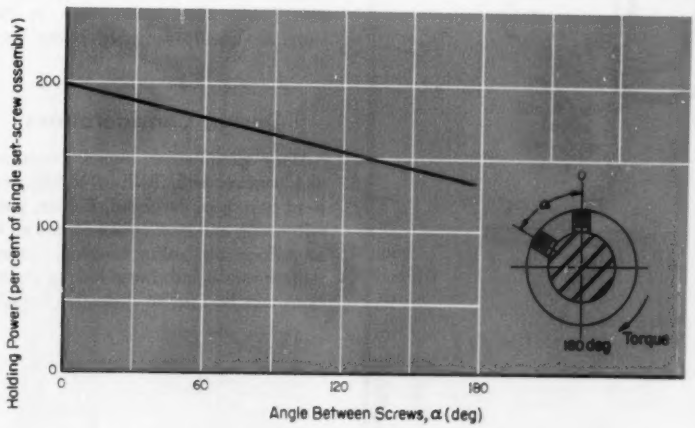


Fig. 4—Angle between two set screws has a straight-line effect on torsional holding-power.

Table 3—Recommended Seating Torques for Alloy-Steel Square-Head Set Screws

Nominal Size (in.)	Seating Torque (lb-in.)	Nominal Size (in.)	Seating Torque (lb-in.)
¼	145	⅝	2550
5/16	300	¾	4500
⅜	500	⅞	7250
7/16	850	1	10,550
½	1275		

Screw Retention

A nut and bolt assembly can be fairly loose and still hold parts together for a considerable time, but as soon as a set screw loosens, the fastened parts normally will separate. An exception is the case of the dog point seated in a drilled hole. Even here, failure would follow rapidly after initial loosening. Seating torque is essential to secure retention of the screw. As the screw, Fig. 1, is tightened, the resultant pressure on the point forces the screw back against the flanks of the threads in the tapped hole, where friction is developed. This friction at the thread flanks plus that at the point of contact of screw and shaft hold the screw in place. The cup point is much better than other points because of high point surface friction. Several screw designs have been developed which have special self-locking features, such as ratchet-like teeth on the face of the point surface.

The set-screw diameter is also a factor in developing vibrational holding power. It does not, however, lend itself to a neat quantitative analysis. In general, a size or two larger set screw may often be the solution in applications where other means have failed to develop satisfactory vibrational holding power. The larger screw permits higher seating torque and thus develops a greater clamping force and higher resistance to loosening.

DESIGN DATA

CHAPTER 12

Sealing Fasteners

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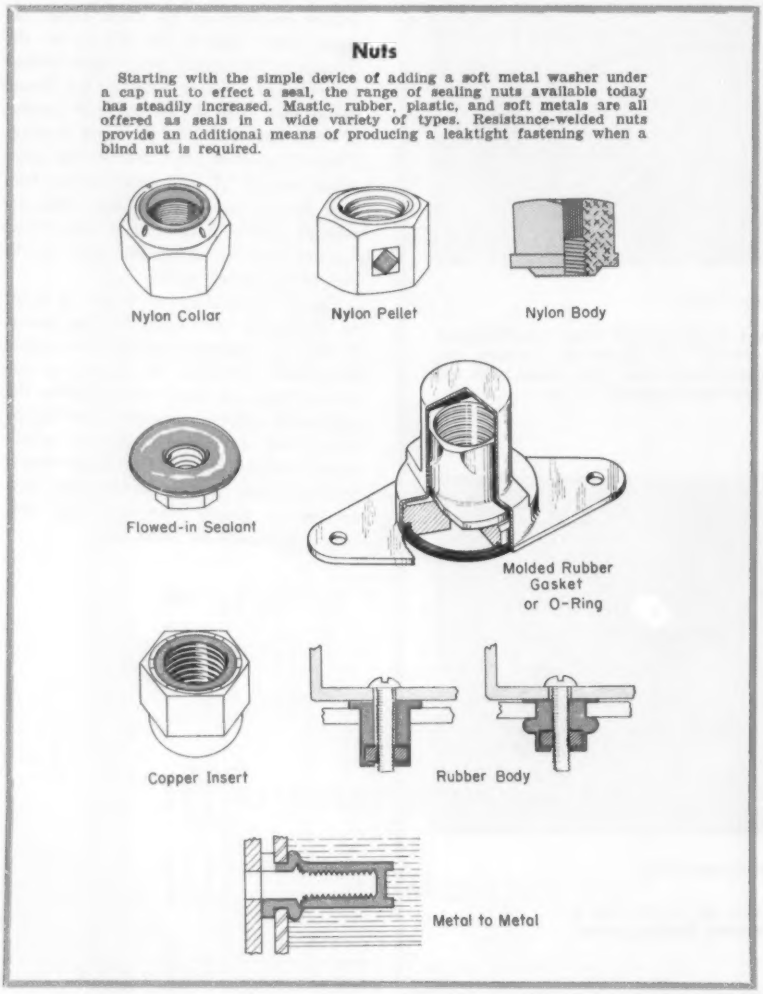
FASTENERS hold two or more parts together—but they can perform other functions as well. One important auxiliary function is that of sealing gases and liquids against leakage.

Two types of sealed-joint constructions are possible with fasteners, Fig. 1. In one approach, the fasteners enter the sealed medium and are separately sealed. A number of fastener designs with built-in sealing elements have been developed for this purpose.


Nuts
Starting with the simple device of adding a soft metal washer under a cap nut to effect a seal, the range of sealing nuts available today has steadily increased. Mastic, rubber, plastic, and soft metals are all offered as seals in a wide variety of types. Resistance-welded nuts provide an additional means of producing a leaktight fastening when a blind nut is required.
Nylon Collar
Nylon Pellet
Nylon Body
Flowed-in Sealant
Molded Rubber Gasket or O-Ring
Copper Insert
Rubber Body
Metal to Metal

The second approach uses a separate sealing element which is held in place by the clamping forces produced by conventional fasteners, such as rivets or bolts.

In pressure-tight joints using conventional bolts or rivets, fastener spacing should be as close as possible and edge distance should be a minimum. Fasteners with fairly large heads, or with washers, should be used. Several sealing methods can be used:

1. Calk the exposed edge of the plate if plate thickness is sufficient.
2. Insert a gasket between plates of a joint.
3. Apply a coat of calking compound or sealant to contact surfaces before joining.

Aircraft fuel tank joints are often made liquid-tight by coating the seams with a heavy resin varnish or other sealer compound. Sometimes, a gasket of varnish-dipped cotton tape or cork is included.

Water-tight joints, good for 15 psi, are made in a similar manner using Neoprene-impregnated tape, soaked in kerosene to make it tacky. All contacting surfaces, rivet holes, rivets, and screws in these joints are usually varnished before assembly.

Design Considerations

Many special rivets, inserts, screws, nuts, and washers with built-in sealing provisions have been developed. Rubber, plastic, soft metals, and interference fits are all used to perform the sealing function. In addition, certain liquid thread-locking compositions can be used to dope the threads of

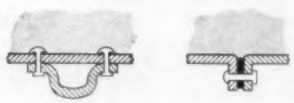
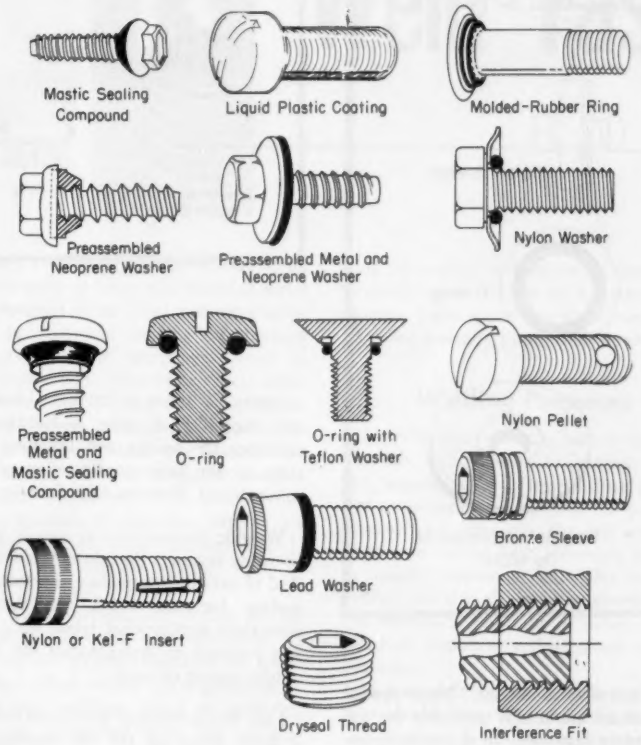


Fig. 1—Types of Sealed-Joint Construction

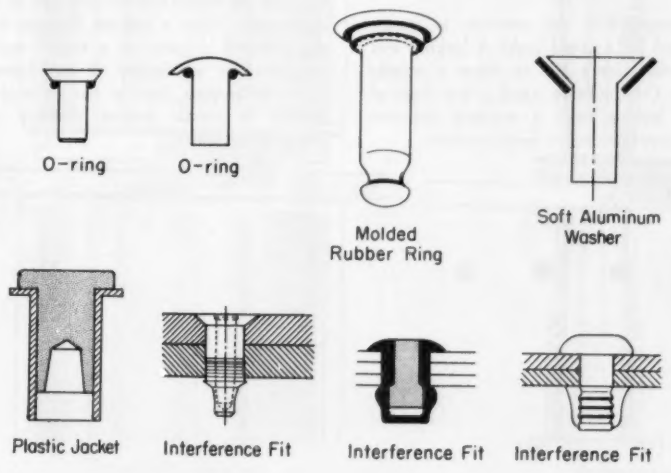
Screws

Most sealing screws provide a sealing action by use of a resilient material added to the screw. It may be rubber, plastic, mastic, or metal. In addition, some screws make use of an interference fit in the threads. For many stud applications such as hanging doors on ovens or insulation on ship interiors, the drilling of holes can be eliminated entirely by resistance welding the stud directly to the metal surface. Chips and oil in blind tapped holes can be locked in by use of sealing screws.



Rivets

Sealing rivets are used extensively in aircraft and ships. They seal integral tanks, pressurized cabins, pontoons and other critical applications. Industrial applications include small gasoline tanks, and the fastening of members to aluminum or plastic boats.



conventional fasteners for sealing. These compositions convert to solid form to produce a plastic-bond which fills the spaces between engaged threads.

The insulating properties of some sealing fasteners make them useful in preventing electrolysis, as well as reducing vibration and noise.

Selection of a sealing fastener is usually a fairly straightforward process. Decide what characteristics are necessary, then pick a specific fastener that provides the necessary seal, and still meets assembly and strength requirements. Basic commercial types of sealing fasteners are shown here. Here are some important selection factors to consider:

Cost: The type of sealing element in a sealing fastener usually determines its cost. If the application is not critical, a number of low-cost elements are available. Be sure to check actual exposure time. Actual exposure time to extreme conditions may be of short duration and a lower-cost sealing fastener may be satisfactory.

Many high per-unit-cost fasteners offer advantages in ease or speed of assembly. Evaluate fastener selection carefully on the basis of actual total installed cost.

Availability: Some sealing fasteners are available from only one source. Some are readily available from a number of suppliers. This point may be significant where high-volume production is involved and multiple sources are necessary to insure uninterrupted supply of parts.

Be alert to the differences in sealing ability between some aircraft and industrial type fasteners. For example, plastic elements in insert-type locknuts may differ in size or material to meet aircraft requirements.

Reliability: Extremes of temperature and pressure will determine the type of sealant that can be considered. In borderline cases, conduct tests to determine the effect of dynamic loading and combinations of conditions. The quality of most seals is greatly affected by the finish on the sealing surface. Avoid sharp burrs and rough surfaces if the seal is critical or the fastener will be re-used. Frequently a sealing fastener will give satisfactory service over a burred hole but will fail if re-used.

Temperature Range: Rubbers vary considerably in their usable temperature range, depending on the particular formulation selected and the type of application. For example, an O-ring sealing at −40 F against vacuum may start to leak whereas the same seal subjected to 100-lb pressure at −65 F will not leak. In many cases the top temperature range can be exceeded by as much as 25 per cent for a short time.

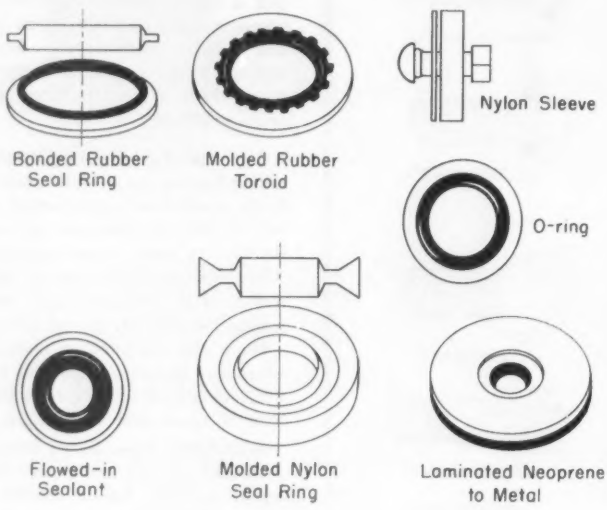
Here are some temperature ranges for typical sealing materials:

Buna-N	− 40 to 300 F
Butyl	− 65 to 250 F
Caprolactum	−120 to 250 F
Kel-F	−320 to 390 F

Washers

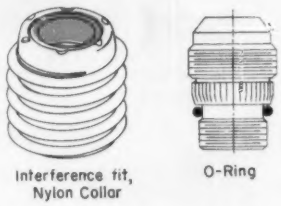
Sealing washers are used either under the screw head or nut. Cut rubber rings, O-rings, or molded-in sections are most commonly used. More recently, flowed-in sealants and nylon rings or sleeves have been made available. For mass-production applications, the sealing washer is offered preassembled to a screw.

The appliance industry uses sealing washers to reduce moisture penetration or to stop water leakage. The automotive industry uses sealing washers to prevent water penetration into the car body, thereby reducing corrosion at the joints.



Inserts

For hydraulic applications sealing inserts provide both the sealing element to eliminate leakage and the increased thread strength and wear resistance frequently needed in plastics, and cast or soft metals.



Neoprene	− 65 to 250 F
Nylon	− 70 to 250 F
Poly-Vinyl Chloride	−100 to 250 F
Silicone	−100 to 500 F
Viton	− 65 to 450 F

Differential Pressure: Mastic sealers flow easily and are usually not used with fasteners for pressures above 100 psi. But, when properly supported, they will resist 2000 lb pressure. Rubber and plastics can resist leakage in the full range from vacuum to 5000 psi or higher, if temperature requirements are moderate.

Mastic or soft elastomeric sealing fasteners are recommended for noncritical applications where surface quality may vary.

Corrosion: Considerable data are available on the resistance of rubbers and plastics to corrosive conditions. Many special formulations are readily available for use with sealing fasteners. In the more severe applications, stainless steel fasteners are usually used with either silicone or Viton rubber, Kel-F, or Teflon.

Chemical reactions between organic sealants and mating surfaces should not be ignored. Staining of surfaces can occur due to sealant plasticizer migration. Test heavily plasticized polyvinyl chloride and mastics to determine if bleeding will be excessive.

Leakage: Will the contents be easily damaged by a slight leak? A leaking fuel tank can start a fire or cause a missile failure. On the other hand, a few drops of water leaking from a washing machine will evaporate before being noticed.

Space: If space is critical, investigate the possibility of using a fastener that combines the sealing and fastening functions in the same configuration as in a conventional (non-sealing) fastener.

Weight: Limitations can usually be met by using fasteners that do not add a great deal of material to produce the seal. Some sealing fasteners weigh less than the equivalent conventional types, since metal was removed to accommodate the lighter weight sealing element.

Life: Environmental conditions will have a direct effect on the life expectancy of sealing fasteners. If not subjected to extreme temperatures or severe corrosive conditions, the rubbers and plastics used in sealing fasteners will give excellent service. Ten to twenty-five years of service is typical.

Reusability: In many consumer applications such as appliances and automobiles there are locations where a sealing fastener will not be distrurbed for the life of the equipment. Here a one-use fastener having a flowed-in gasket or a mastic sealing compound is satisfactory. If the fastener is to be re-used then a cut or molded rubber or plastic sealing element will probably be better.

DESIGN DATA

CHAPTER 13

Weld Fasteners

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SIMPLY defined, a weld fastener is an externally or internally threaded metal part designed to be fused permanently in place by resistance welding on standard production-welding equipment. Scope of this chapter will be limited to these types of fasteners and will not deal with custom welding systems, generally referred to as stud welding, in which the fasteners are designed for use with a special welding machine.

Two methods of resistance welding are used to attached these fasteners, Fig. 1:

1. Projection welding.
2. Spot welding.

With either method, the fusion of the fastener to the metal part surface is the result of the natural resistance of metal to a controlled current under pressure.

The most common forms of weld fasteners are screws and nuts. Pins are also available, but generally serve as a locating or bearing surface, rather than as a fastener, when applied as a welded component. From a selection standpoint, these pins are basically unthreaded screws.

Welding Processes

In projection welding, heat is localized through embossments or projections on the fastener. During the welding process, the projections coalesce with the part surface to form the weld. For best results, a press-type welder with electronic controls is usually recommended. This type of welder has the air cylinder directly over the electrodes, resulting in more positive electrode alignment and equalized welding pressures.

In spot welding, the current is directed through the entire area under the electrode tip. Welding is usually performed by a rocker-arm type spot welder which has the air or hydraulic cylinder on the back of the machine. Sometimes, mechanical springs are used for applying pressure. Length of the rocker arms may range from 12 to 60 in. This type of welding equipment was originally designed for spot welding large sheets; however, a number of fastener designs which can be satisfactorily welded with this equipment have been developed.

Although these welding processes are similar in many respects, there are certain basic differences that should be recognized. Cost of spot welding equipment is considerably less than for projection welding. However, the projection welder is a much more flexible piece of equipment and permits far greater latitude in design. The main advantage of spot welding is that it provides a means of attaching a fastener when the assembly itself is being fabricated. Where spot welding is a normal

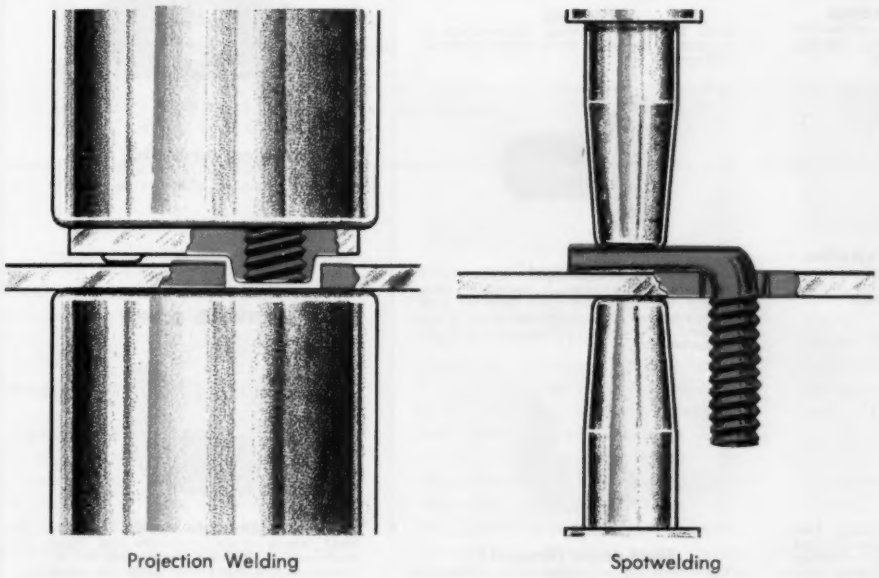


Fig. 1—Basic methods for attaching weld-fasteners

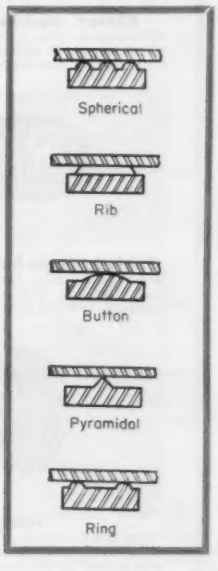
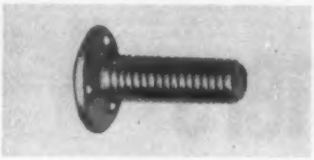


Fig. 2—Basic types of weld projections

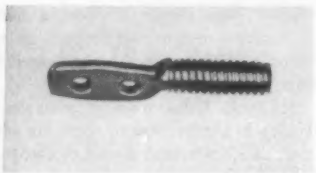
Table 1—Basic Types of Weld Fasteners

PROJECTION WELD SCREWS

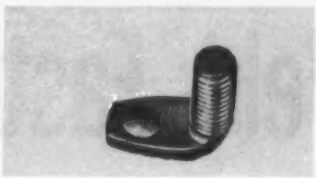


Through-hole
Self-locating for through-hole applications. Provides high strength and flush surface for mating parts.

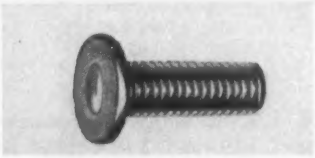
Blind-location
Provides unmarred exterior. Requires no holes in sheets and no electrode insulation.



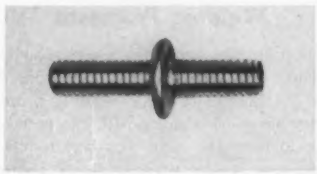
Spade
Used where a threaded section is required on the edge of a sheet.



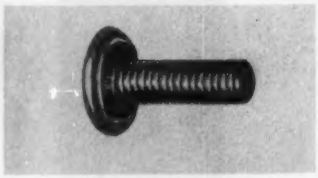
Right-angle spade
Used in confined locations or channels.



Button-projection
Easily welded to curved surfaces. Recommended for use on heavy sheets, 3/32 in. thickness and over.



Double-end
Provides a hermetic seal and a threaded section on both sides of the sheet. Widely used on transformer cans.



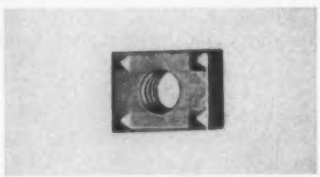
Watertight
Self-locating screw which provides complete hermetic seal. Ideal for welding to perforated sheets.

PROJECTION WELD NUTS

Piloted, dual-line projection
Self-locating pilot. Ideal in applications where tension is against the weld. Readily adaptable to automatic feeding.

Piloted, single-button projection
Self-locating pilot. Ideal in confined areas and channels. Easily welded to curved surfaces and heavier gage sheets.

Flanged
Projections on top or under flange. Provides extra-long thread engagement and also serves as bearing surface, mounting surface, or spacer. T-shape head used primarily in confined areas.



Pilotless
Ideal for blind locations where there is no hole in the sheet or on slightly curved surfaces.

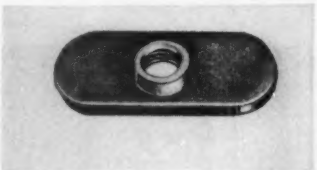
Watertight
Ring projection provides hermetic seal. Round body nut has blind threaded hole for completely watertight fastening. Widely used on air conditioning equipment and transformers.

Right-angle (Bracket)
Used when it is necessary to attach a nut at a 90 deg angle.

SPOT WELD NUTS

Piloted, target
Self-locating pilot and recessed target electrode area. Ideal where other spotwelds are being made and the required nut can be attached with the same equipment and settings. Can be welded with low KVA capacity equipment.

Piloted, single-tab
Self-locating pilot. Can be welded with same settings and electrodes used to join components.



Piloted, double-tab
Self-locating pilot. Ideal for bridging corners or sections, or where extra strength is needed.

SPOTWELD SCREW

Right-angle spade
Ideal where other spotwelds are being made and a threaded section can be attached at the same time with the same equipment and weld set-up.

Table 2—Welding Characteristics of Common Engineering Materials

Part Material	Welding Characteristics*	Recommended Weld Fastener*	Remarks
Steel			
Low-carbon, cold rolled. 1008-1018 max	Excellent results, especially with sheet thicknesses from 0.030 to 0.187 in.	All types	Special projections necessary when welding to extremely thin sheet or plate thicker than 3/16 in.
Low-carbon, hot rolled. Pickled and oiled or scale removed by other means.	Excellent results.	All types	Single button projections recommended when welding to heavy plate.
Low-carbon, hot rolled. Not pickled, scaly stock.	Generally poor results. Welds will be inconsistent and erratic. Weld failures common. Scale acts as insulator and must be broken through before a resistance at the interface can be developed.	Single-button type projection-weld fasteners only	Large single-button projection-weld parts can break through to form a weld if the scale is not too thick. Consistent good welds cannot be obtained.
Low-carbon sheet, plated. Electro-zinc, cadmium, copper, nickel plate.	Excellent results. Slight burning of plating at weld zone.	All types	Use short weld time and increase hold time cycles to minimize discoloration.
Low-carbon sheet, precoated. Galvanized, lead-zinc (terne), aluminized, paint-loc, zinc grip, etc.	Similar to electro-plated sheets.	All types	Electrodes must be water cooled as near to welding surface as possible. Electrode pickup is great and must be re-faced or re-dressed at frequent intervals.
Low-carbon sheet, prefinished. Parkerized, black oil, or similar finishes.	Inconsistent results. These finishes are very poor conductors of electricity.	None	Not recommended. Welding should be done first and finish added afterward.
High carbon Over 0.20 C.	Welds usually are very brittle and will fail under strain.	Single-button type projection-weld fasteners only	Special preheat and postheat or tempering-cycle-time controls necessary.
Stainless Steel 18-8; Types 302, 305, 321, 347. (Austenitic)	Excellent results in thicknesses from 0.060 to 0.125 in. Some heat-shrink markings in weld zone for thicknesses under 0.060 in.	Projection-weld type	Shorter weld time and higher pressures must be used in comparison to low-carbon steel.
Types 410-416 (Martensitic)	Very poor results, if any.	None	Not recommended.
Type 430 (Ferritic)	Good results with thin gages under 0.060 in. thick. Fair, brittle welds above 0.060 in.	Projection-weld type	Subject to excessive grain growth, causing brittle welds.
Monel	Similar to 18-8 stainless steel.	Projection-weld type	Higher welding pressures necessary than for comparable mild steel.
Brass Yellow. Naval or high brass.	Good results, especially with thicknesses under 0.093 in.	Projection-weld type	Fast or short weld-cycle time required, with higher pressures. Press-type welders with electronic controls necessary.
Red.	Very poor, if any.	None	Not recommended.
Aluminum	Unsuitable	None	Not recommended.
Copper	Unsuitable	None	Not recommended.

*Data apply to low-carbon steel weld fasteners only.

part of the production operation, the use of fasteners designed for this welding process can eliminate set-up time and increase the flexibility of this equipment.

General Design Considerations

Representative styles of weld fasteners and their intended functions are summarized in Table 1.

Before any of these fasteners can be used, four basic requirements must be met:

- The materials to be joined, both part and fastener, must be suitable for resistance welding. The material most commonly used for weld fasteners is low-carbon steel, such as 1010. Table 2 gives the general welding characteristics of other materials when used with low-carbon steel fasteners. Welding results with stainless steel fasteners are comparable although, generally speaking, more closely controlled welding is required. Aluminum weld fasteners are recommended only for spot-welding to compatible grades of aluminum.
- The parts to be welded must be portable enough to be carried to the welder. Use of portable welding equipment with these types of fasteners is generally not recommended.
- Production volume should be great enough to justify tooling costs. As a general rule of thumb, a quantity of at least 1000 parts is generally considered necessary to make the application of weld fasteners feasible from a cost standpoint.
- Suitable welding equipment must be available.

Properly integrated into an assembly, weld fasteners can often speed up and simplify production and assembly operations to provide a significant cost advantage over other fastening methods. Pre-

Guide to Weld Fastener Selection

Use projection-weld fasteners when

- Suitable projection welding equipment is available.
- Appearance is an important consideration. Projection welding does not mark the surface on the opposite side of the weld.
- Simultaneous welding of multiple fasteners is required.
- Spacing between fasteners must be kept close.
- Fasteners must be welded to part sections of varying thicknesses.
- Fasteners must be welded to parts of unusual shape or a watertight weld joint is required.
- Welding fixtures can be used for easier locating or automatic feeding.
- Length of production run without maintenance is critical.

Use spotweld fasteners when

- Suitable rocker-arm welding equipment is available.
- Appearance of the part surface opposite the weld is not critical. Spot welding leaves a slight indentation from the electrode tips.
- Other spot welds are being performed on parts of the assembly.
- Length of production run without maintenance is not too important. Spot-welding electrode tips will mushroom to some extent in production welding. Shorter runs before refacing or redressing must be expected.
- Dissimilar materials, such as aluminum, copper, or magnesium, are being welded.
- Shape, size, or space requirements do not permit use of projection welded fasteners.

attached in the early stages of manufacture, they provide a permanent primary fastener that will not come loose under vibration. They are ideally suited for use in inaccessible or blind locations where wrenching would be difficult or impossible, or on sheet metal parts where a threaded section is required.

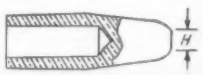
Greatest current usage of weld fasteners is with sheet metal parts in the thickness range from 0.030 to 0.125 in. However, weld fasteners can be used with any part shape or thickness that can be handled by the welding equipment. Although general rules governing the relationship between part thickness and fastener size have been proposed, experience has shown that virtually any fastener size can be welded to any thickness of material as long as the materials are compatible, the welding operation is controlled, and the fastener itself is properly designed.

In the design of assemblies where weld fasteners are to be used, a thorough knowledge of the production operation involved is essential if optimum results are to be achieved. Since design of the part will have a major influence on the sequence of the production operations, failure to understand the limitations and requirements of existing facilities can lead to costly production problems and solutions.

Where suitable welding equipment is available, use of weld fasteners should be considered in design when:

- The assembly requires any resistance welding of parts, sections, or braces. In such circumstances, a weld fastener can often be welded in place along with the other parts to speed up the over-all production and assembly program.
- The assembly requires a threaded section on a sheet metal part or plate member. Welding a nut in place to serve as a thread anchor is often a more convenient and faster solution, with cost advantages, to the problem than forming and tapping a hole.
- The fastener must be mounted in a location where wrenching or subsequent assembly operations would be difficult or impossible with conventional fasteners.
- Hidden fasteners are required in blind locations. Weld fasteners, either screws or nuts, can be readily attached to the enclosed side of a sheet metal or plate section.
- Loosening of a fastener under vibration or shock is a critical problem.
- A permanent fastener attachment is required to avoid loose parts that might fall into equipment or get lost in assembly.
- A hermetically sealed fastener is required. Use of a sealing-type weld fastener can eliminate the need for separate sealing elements.

Table 3—Recommended Electrode Tip Diameters for Spot Welding



Thickness of Sheet or Nut (in.)	Tip Diameter, H (in.)	Welding Pressure (lb)	Weld Time (cycles)	Welding Current (amp)
0.016	1/8	200	4	7,000
0.031	5/32	300	5	9,500
0.047	7/32	500	6	10,800
0.062	9/32	600	8	13,200
0.078	5/16	800	9	14,900
0.094	11/32	900	10	16,600
0.109	13/32	1100	12	18,100
0.125	15/32	1300	14	19,600
0.141	17/32	1500	18	21,300
0.156	19/32	1800	22	23,000
0.172	21/32	2000	28	24,500
0.187	23/32	2300	32	26,000
0.203	1	2500	38	28,000

Fastener Selection

Three major considerations are important in the selection of a particular weld

part and the welding method:

- Is fastener strength — tension, torsion, or shear—of key importance?
- Is appearance important? Would it be advantageous to protect the exterior surfaces from markings, discolorations, etc.?
- Is compactness important? Must the fastener be used in a minimum space or confined area?

Conditions under which spot and projection-welded fasteners should be used are given in *Guide to Weld Fastener Selection.*

An important consideration in the selection of a specific projection-welded fastener concerns the type of projection used to produce the weld, Fig. 2. For general purpose application when welding to sheet metal in the 0.030 to 0.125 in. thickness range, multiple spherical projections are recommended. Most manufacturers advocate three equally spaced projections because they tend to equalize themselves if the electrodes are in reasonable alignment.

A single button-type projection will give the best results when welding to metal thicknesses over 0.125 in. or to curved surfaces, tubing, etc. The rib-type projection will give very strong welds and is ideal where tension is against the weld. In confined areas or on slight curved surfaces, the pyramidal type is usually recommended. Where a gas, air, oil, or watertight seal is required, the 360-deg ring projection is the best, but requires welding equipment of greater capacity than for the other types of projections.

Recommended Design Practices

One of the important considerations in weld-fastener selection is fastener size. Where strength is a key factor, the same rules apply as for any other fastener. Weld fasteners are generally designed so that the strength of the combined welded area is greater in tension, shear, and torsion than the weakest part of the fastener. That is, fasteners welded to sheet metal parts through the thickness range from 0.030 to 0.125 in. will fail in the threaded portion before the weld fails.

When neither appearance nor strength is a significant factor, fastener size should be chosen on the basis of existing tooling and available stock parts. Often, clearances will play a controlling role in determining the size of a weld fastener.

Edge distance can also be important. With spot-welded fasteners, the center of the fastener should be at least 1½ electrode tip diameters from the edge of the sheet. This dimension will vary with sheet thickness which controls electrode size, Table 3.

Where through-hole screws or nuts are used, the diameter of the hole in which the fastener is located should be at least 0.010 to 0.015 in. oversize. This clearance is generally considered optimum from the standpoints of handling ease and weld-spatter elimination. A smaller clearance will hinder positioning of the fastener. A larger clearance may lead to misalignment and faulty welds. An important point to keep in mind is that through-hole fasteners eliminate the need for locating templates, jigs, and fixtures since that function is served by the locating hole.

Where hidden fasteners are required, consideration should be given to the possible jig and fixture problems that may be involved in locating the parts for welding.

Clearance between adjacent fasteners may also be a problem if spot welding is used. The distance between fasteners should be at least 3½ electrode tip diameters. Otherwise, "shunting" may occur through the previous spot welds and produce faulty results. In projection welding, there is no restriction on clearance between adjacent fasteners. If necessary, the fasteners can be mounted side by side.

When multiple fasteners are simultaneously welded on projection welding equipment, try to keep center-to-center distances to a minimum. This practice keeps current requirements down and eliminates need for special provision to equalize pressures at the weld area.

Avoid combinations of spot and projection-welded fasteners on the same assembly. This practice can lead to extra material-handling operations and added costs.

Use nuts as the welded parts wherever possible. Subsequent production handling of assemblies with screws attached could lead to thread damage. With nuts, where the threads are concealed, this danger is reduced.

When multiple fasteners are required on a single assembly, consider standardizing on one size. Although this type of standardization may lead to "overdesign" in some places, it will usually be justified by the advantages gained in materials handling, assembly, production, and inventory simplification.

Where clearance conditions or part shape indicate a need for special welding electrodes, consider reversing the fastener assembly. That is, if a weld screw with a conventional nut has been specified, try changing over to a weld nut and a conventional screw.

Make sure there is enough edge distance to allow room for a standard electrode or fastener. Often, just an amount equal to the thickness of the part selection can make the difference. For example, where a fastener head abuts tight against a wall, a hole might be punched in the wall to provide full head clearance. Providing the extra clearance necessary to accommodate a standard fastener head or electrode, can lead to cost savings and greater production efficiency.

DESIGN DATA

CHAPTER 14

Pin Fasteners

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Associate Editor, MACHINE DESIGN

SIMPLE in form, pin fasteners offer a neat, effective approach to assembly where loading is primarily in shear. A number of pin devices have been developed to meet a wide range of varying application and assembly requirements. Pin fasteners can be conveniently separated into two groups:

1. **Semipermanent:** Those pin fasteners that require application of pressure or the aid of tools for installation or removal. Representative types include the various grooved-surface and spring pins, as well as conventional taper, dowel, clevis, and cotter pins.

Two basic types of pins offer potential application as semipermanent fastener elements:

a. Machine pins
b. Radial-locking pins

2. **Quick-Release:** The more elaborate self-contained pin devices which have been developed for rapid manual assembly or disassembly. Most of these pin types employ some form of detent mechanism to provide a locking action in assembly.

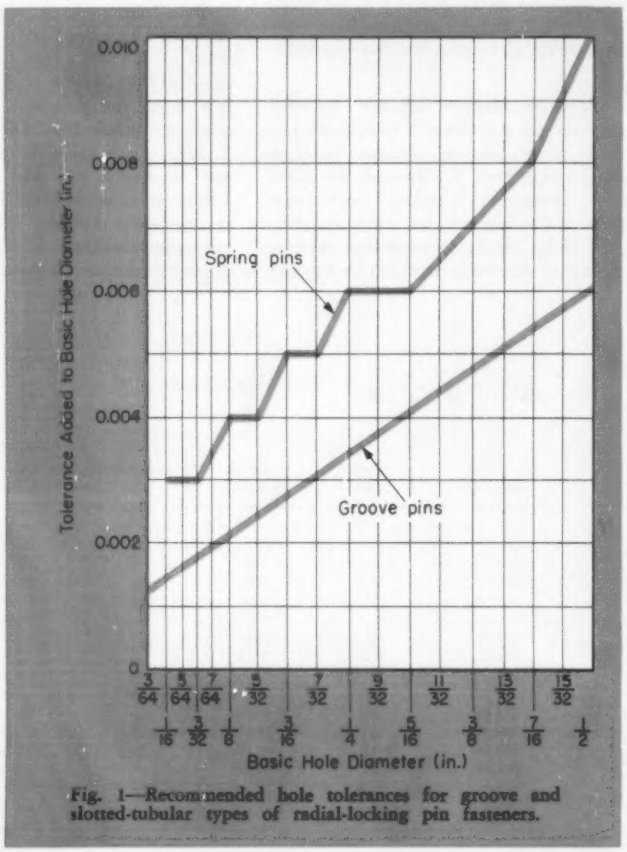


Fig. 1—Recommended hole tolerances for groove and slotted-tubular types of radial-locking pin fasteners.

Machine Pins

A number of pin forms have been standardized by ASA under the designation of machine pins (*American Standard Machine Pins—ASA* B5.20-1958). One of these pin forms—the grooved straight pin—is actually a radial-locking type pin and will be covered in a later section of this chapter. Although all of the other standard pin forms can be adapted to fastening service, attention will be given here only to those types considered to be the most important. Table 1 presents the four traditional forms of machine pins.

Radial Locking Pins

Low cost, ease of assembly, and high resistance to vibration and impact loads are common attributes of a group of commercial pin devices designed primarily for semipermanent fastening service. Two basic pin forms are employed: Solid with grooved surfaces, and tubular. In assembly, radial forces produced by elastic action at the pin surface develop a secure, frictional locking grip against the hole wall. These pins are re-usable and can be removed and reassembled many times without appreciable loss of fastening effectiveness. Live spring action at the pin surface also prevents loosening under shock and vibration loads. Need for accurate sizing of holes is reduced since the pins accommodate a range of variation.

Grooved Straight Pins: Locking action of the groove pin is provided by parallel, longitudinal grooves uniformly spaced around the pin surface. Rolled or pressed into solid pin stock, the grooves act to expand the effective pin diameter. When the pin is driven into a drilled hole corresponding in size to nominal pin diameter, elastic deformation of the raised groove edges produces a secure force-fit with the hole wall.

Table 1—Machine Pins

HARDENED & GROUND DOWEL PIN

Standardized in nominal diameters ranging from ⅛ to ⅞ in. Standard pins are 0.0002 in. oversize on the nominal diameter; oversize pins are 0.001 in. oversize.

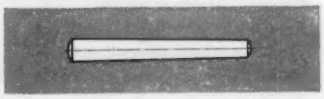
Standardized pin lengths vary with nominal diameter, ranging from a minimum of ½ in. (⅛ in. size) to a maximum of 5½ in. (⅞ in. size).

Standard tolerance on all pin diameters is +0.0001 in. A typical manufacturer's specification for such pins is: Material, heat-treated alloy steel; surface hardness, Rockwell C 60-62; core hardness, Rockwell C 50-54; surface finish, 6 mu in. max; and average single-shear strength, 150,000 psi.

A press or tap fit into reamed holes recommended. Secondary reaming operation is often omitted where production requirements do not justify the refinement.

Used for:

1. Holding laminated sections together with surfaces either drawn up tight or separated in some fixed relationship.
2. Fastening machine parts where accuracy of alignment is a primary consideration.
3. Locking components on shafts, in the form of a transverse pin key, where a secure, high-strength joint with minimum stress concentration under severe torque loads is desired.
4. Can be used for combination functions as a locking fastener and hinge, wrist pin, or small stub shaft in moving parts.



TAPER PIN

Standard pins have a taper of ¼ in. per ft measured on the diameter. Basic dimension is the diameter of the large end. Diameter d of the small end is given by $d = D - 0.02083L$ where D = diameter of large end, in., and L = pin length, in.

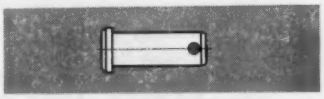
A series of numbered pin sizes has been standardized, ranging from No. 7/0 (0.0625 in. large end) to No. 10 (0.7060 in large end). Lengths for these pins, depending on diameter of large end, vary from ⅝ to 6 in. Full range of manufactured sizes includes No. 8/0 (0.047-in. large end) to No. 14 (1.523 in. large end) in standard and nonstandard lengths.

Two manufactured grades are recognized: Commercial type, without a concavity tolerance, in sizes 7/0 to 14; and Precision type, with concavity tolerance, in sizes 7/0 to 10. Available pin materials include mild, stainless, and alloy steel and brass.

Holes for taper pins are customarily sized by reaming. A through hole is formed by step drills and straight fluted reamers. Present trend is toward the use of helically fluted taper reamers which provide more accurate sizing and require only a pilot hole the size of the small end of the taper pin. Pin is usually driven into the hole until it is fully seated. Taper of the pin aids hole alignment in assembly.

Used for light-duty service in the attachment of wheels, levers and similar components to shafts. Torque capacity is determined on the basis of double shear. Using the average diameter along the tapered section in the shaft for area calculations.

Modifications have been developed to meet nonstandard design situations. For joints where a slotted construction is employed for assembly, a taper pin milled flat along one surface provides an effective wedge fastener for locking the members securely. In locations where access to either end of the taper pin is blocked a threaded section may be incorporated in the accessible end to facilitate pin installation or removal. Other common modifications include special head shapes and split-end constructions.

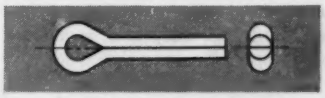


CLEVIS PIN

Standard nominal diameters for clevis pins range from $\frac{3}{16}$ to 1 in. Corresponding shank lengths vary from $\frac{11}{16}$ in. for $\frac{3}{16}$-in. size to 2⅝ in. for 1-in. size. Standard material is steel, either soft or cyanide-hardened to meet service conditions.

Basic function of the clevis pin is to connect mating yoke, or fork, and eye members in knuckle-joint assemblies. Held in place by a small cotter pin or other fastening means, it provides a mobile joint construction which can be readily disconnected for adjustment or maintenance.

Several designs have been developed to meet special conditions. Common modifications include slotted and noncircular-head constructions as well as threaded ends for assembly with standard nuts or into internal thread sections tapped into one of the yoke arms.



COTTER PIN

Eighteen sizes have been standardized in nominal diameters ranging from $\frac{1}{32}$ to ¾ in. Available materials include mild steel, brass, bronze, stainless steel, and aluminum. Available in a number of point styles, shown in *Standard Cotter-pin Point Styles*.

Locking device for other fasteners. Used with a castle or slotted nut on bolt, screws, or studs, it provides a convenient, low-cost locknut assembly.

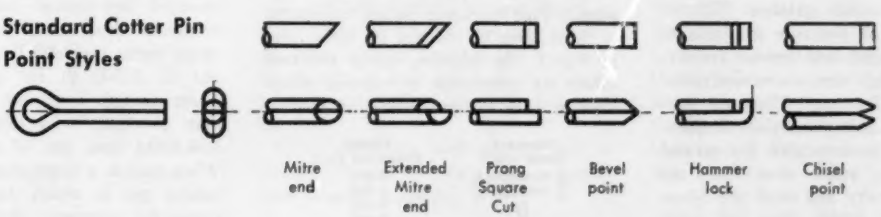
Hold standard clevis pins in place. Can be used with or without a plain washer as an artificial shoulder to lock parts in position on unthreaded or threaded rods and shafts. Cotter-pin sizes used with various shafts are shown in *Recommended Assembly Practice for Standard Cotter Pins*.

Recommended Assembly Practice for Standard Cotter Pins

Nominal Thread Size (in.)	Nominal Cotter Pin Size (in.)	Cotter Pin Hole (in.)	End Clearance* (in.)
1/4	1/16	5/64	7/64
5/16	5/64	3/32	7/64
3/8	3/32	7/64	9/64
7/16	3/32	7/64	11/64
1/2	1/8	9/64	11/64
9/16	1/8	9/64	13/64
5/8	5/32	11/64	15/64
3/4	5/32	11/64	17/64
7/8	5/32	11/64	9/32
1	3/16	13/64	5/16
1 1/8	3/16	13/64	25/64
1 1/4	7/32	15/64	13/32
1 3/8	7/32	15/64	7/16
1 1/2	1/4	17/64	31/64
1 5/8	1/4	17/64	31/64
1 3/4	5/16	5/16	35/64
1 7/8	5/16	5/16	35/64
2	5/16	5/16	41/64
2 1/4	5/16	5/16	41/64
2 1/2	3/8	3/8	3/4
2 3/4	3/8	3/8	3/4
3	1/2	1/2	3/4

*Distance from extreme point of bolt or screw to center of cotter pin hole.

Standard Cotter Pin Point Styles



Six groove constructions have been standardized by ASA, Table 2. Standard pin sizes cover a range of nominal diameters from 3/64 to ½ in. in varying lengths from ⅛ to 4½ in. Standard materials include cold-drawn SAE 1112, 1113, and 1212 steel, alloy steel, stainless steel, and copper alloy.

For standard groove pins made of B 1112 steel, load capacity in single shear varies from about 110 lb for 3/64 in. size to 12,800 lb for ½ in. size.

Locking force developed by a groove pin in assembly is a function of pin diameter and effective length of engagement. As either one or both of these variables are increased, holding action, along with forces required for pin insertion and removal, are increased.

Best results under average assembly conditions are obtained with holes drilled the same size as the nominal pin diameter. Undersize hole specifications should be avoided. This practice can lead to deformation of the pin in assembly, damage to hole walls, and shearing-off of the raised groove edges, thus reducing holding action and preventing re-use of the pin. When the part material is appreciably harder than that of the pin, chamfered or rounded hole edges should be specified to avoid shearing of the expanded pin section.

Recommended hole tolerances for groove pins are depicted graphically in Fig. 1. These values, which are added to the basic hole diameter (nominal pin diameter), apply generally to steel pins where the ratio of engaged length to diameter is not less than 4:1 or more than 10:1 and a strong locking action is desired. As the length-diameter ratio decreases, tolerances become more critical and should be held closer than the chart values.

Spring Pins: Resilience of hollow-cylinder walls under radial compression forces is the principle of two pin forms, Fig. 2, developed for fastening application. Both pin forms are made to controlled diameters greater than the holes into which they are pressed. Compressed when driven into the hole, the pins exert spring pressure against the hole wall along their entire engaged length to develop a strong locking action.

Spiral-Wrapped Pins: Standard sizes of these pins cover a range of nominal diameters from 1/32 to ½ in. in lengths from ⅛ to 4 in. Standard materials are heat-treated 1070 carbon steel, heat-treated chrome-alloy stainless steel (410), and work-hardened nickel stainless (302).

Three series of pins are available to meet varying load and service requirements. Light-duty pins are recommended for low shear loading. They are suitable for use in soft materials. Medium-duty pins are recommended for general fastening service where shear loads are of medium intensity, and shock and vibration loads are greater than the static shear loads. Heavy-duty pins are recommended for extreme service conditions where shock and vibration loads are severe but are smaller than the static shear loads. In selection of pin sizes for key applications in shafts, data given in Table 3 may be used as a guide.

Fig. 3 may be used to select a pin size if it is desirable to have the pin fail before the shaft, or vice versa. Fig. 3 can be applied to any kind of pin or pin material. To use it on taper pins, figure the pin radius to be one-half of the sum of the large and small radii of the pin at the plane where the pin intersects the shaft. To apply Fig. 3 to hollow spring pins, find the shear yield strength (lb) of the pin, then divide this value by the nominal area of the pin, $\pi d^2/4$, where d = nominal diameter, in. This gives the value of the shear yield strength (psi) of an equivalent solid pin.

Recommended hole tolerances are more liberal for spiral pins than for other pin types. Plus tolerance values correspond to those given by the plot for spring pins in Fig. 1. In addition, minus tolerance values are permissible on nominal diameters of 1/16 in. and greater as follows:

Nominal Diam (in.)	Minus Tolerance (in.)
1/16 through 3/32	0.001
7/64 through 11/64	0.002
3/16	0.004
7/32	0.007
1/4	0.008
9/32 through 1/2	0.010

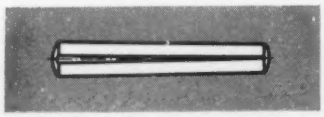
Locking force developed by a spiral-wrapped pin is a function of length of engagement and pin diameter.

Slotted Tubular Pins: Standard sizes are from 1/16 to ½ in. in lengths from ⅛ to 5½ in. Standard materials are heat-treated carbon steel, corrosion-resistant steel, and beryllium copper.

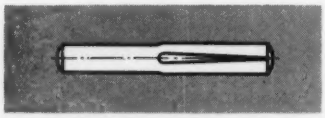
Readily adaptable to manual or power-assembly techniques, these pins offer a tough yet resilient, self-locking fastener that can withstand high shock and vibration loads. Under normal application conditions, holes produced with standard fractional drills and held within the practical tolerances shown in Fig. 1 for spring pins will provide satisfactory locking action. Punched or preformed holes that meet tolerance recommendations of Fig. 1 are also acceptable.

Recommended practices in the selection of slotted tubular pins for key applications in shafts are given in Table 3. For standard heat-treated carbon-steel pins, minimum double-shear strength (transverse) varies from 425 lb for the 1/16-in. size to 25,800 lb for the ½-in. size. These strength levels are slightly higher than provided by a solid mild-carbon, cold-rolled steel pin of equivalent size. When used as a longitudinal key, a slotted tubular pin in which the length is 2½ times the diameter develops a shear strength equal to the double transverse

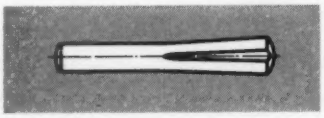
Table 2—Grooved Straight Pins



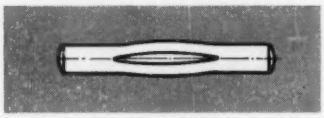
Type A
Full-length grooves. Used for general-purpose fastening.



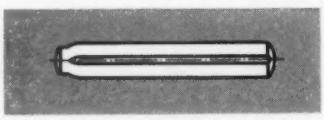
Type D
Reverse tapered grooves extend half the pin length. It is the counterpart of the Type B pin for assembly in blind holes.



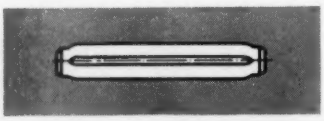
Type B
Grooves extend half length of the pin. Used as a hinge or linkage "bolt" but also can be employed for other functions in through-drilled holes where a locking fit over only part of the pin length is required.



Type E
Half-length groove section centered along the pin surface. Used as a cotter pin or in similar functions where an artificial shoulder or a locking fit over the center portion of the pin is required.



Type C
Full-length grooves with pilot section at one end to facilitate assembly. Expanded dimension of this pin is held to a maximum over the full grooved length to provide uniform locking action. It is recommended for applications subject to severe vibration or shock loads where maximum locking effect is required.



Type F
Full-length grooves with pilot section at both ends for hopper feeding. Same as Type C.

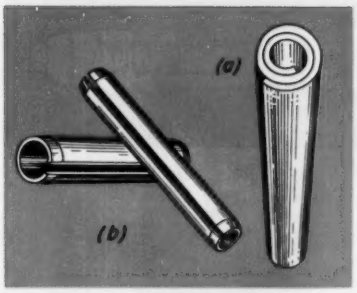


Fig. 2—Spring-pin fasteners showing, *a*, spiral wrapped designs and, *b*, slotted tubular design.

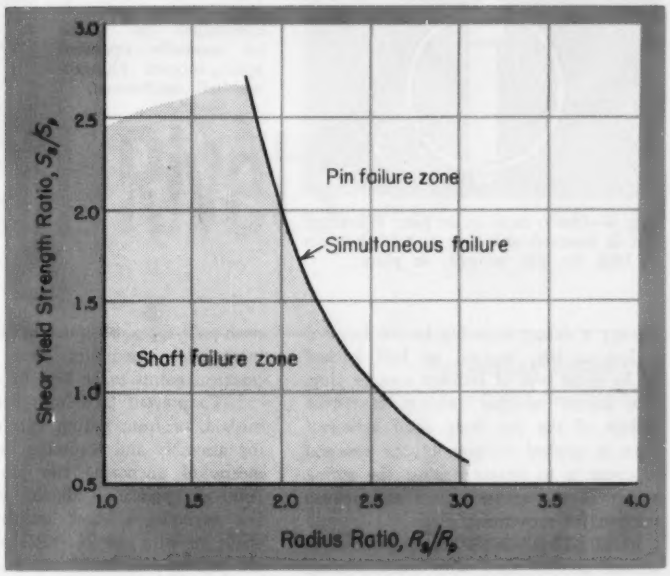


Fig. 3—Chart for determination of optimum ratio of pin radius to shaft radius for transverse-key solid pin. Shear yield strength (psi) ratio of shaft material, S_s, vs. pin material, S_p, is plotted against ratio of shaft radius, R_s, vs. pin radius. R_p. Values falling to the left and below the line mean that the shaft would fail before the pin failed. (Based on data from "Pin Keys," by Jack Paul, MACHINE DESIGN, April 3, 1958).

shear strength of the pin.

The foregoing shear-strength values are based on tests made with the pin slot positioned 90 deg from the direction of load application. For maximum shear strength, the pin should be assembled so that the gap is in line with the direction of load and 180 deg away from the point of application. The maximum shear strength value provided by this gap orientation represents an increase of about 6 per cent over the minimum value.

A method of increasing shear strength is to use pins in combination. Standard slotted tubular pins have been designed so that several sizes can be used inside one another. For example, a 3/32-in. size pin can be used in combination with one of 5/32 in. size. In such combinations, shear strengths of the individual pins are additive. Thus, the foregoing example, which combines individual strengths of 1000 and 3000 lb, provides a total double-shear strength of 4000 lb.

Table 3—Recommended Assembly Practices for Radial-Locking Pins

Shaft Diam (in.)	Transverse Key Pin Diam (in.)	Taper Pin No.	Longitudinal Key Pin Diam (in.)
3/16	1/16	7/0	...
7/32	5/64	6/0	...
1/4	3/32	5/0	1/16
5/16	7/64	4/0	5/64
3/8	1/8	3/0	3/32
7/16	5/32	0	1/8
1/2	5/32	0	1/8
9/16	3/16	2	5/32
5/8	3/16	2	5/32
11/16	7/32	3	3/16
3/4	1/4	4	3/16
13/16	1/4	4	...
7/8	1/4	4	7/32
15/16	5/16	5	1/4
1	5/16	6	1/4
1 1/16	5/16	6	...
1 1/8	3/8	7	...
1 3/16	3/8	7	...
1 1/4	3/8	7	5/16
1 5/16	7/16	7	...
1 3/8	7/16	7	3/8
1 7/16	7/16	7	...
1 1/2	1/2	8	7/16

In double-pin assemblies, random orientation of slots is recommended. Also, when double pins are installed, it is recommended that the hole dimension be held to the high side of the tolerance to facilitate insertion. Advantages of the double pin construction include high resistance to impact loads and increased fatigue strength.

As a guide to selection and application of slotted-tubular pin fasteners, certain rules of good design practice have been established and are presented here. Most of them are equally valid for all types of pin fasteners.

Avoid conditions where the direction of vibration parallels the axis of the pin fastener. Although the slotted tubular pin can withstand the loosening effect of vibration in most applications, unusual conditions can result in an axial vibration component that bears careful evaluation. In such instances, accelerated vibration testing of prototype assemblies is advised.

Keep the shear plane of the pin a minimum distance of one diameter from the end of the pin.

In applications where engaged length is a minimum and appearance is not critical, allow pins to protrude the length of the chamfer at each end to develop maximum locking effect over the engaged length.

When deflection load on the pin is critical (closing of the gap), consider these possible solutions:

1. Increase pin diameter and length.

2. Increase shaft diameters in key applications. This will decrease the shear load on the pin and permit a higher torque to be transmitted with less deflection.

3. Reduce hole tolerance. The closer the hole is to minimum recommended size, the smaller will be the pin deflection.

4. Increase the length of the pin. Extending the length of the pin even beyond the edge of the hole into which it is inserted will lessen the amount of deflection.

5. Use a double-pin assembly or two pins of equal size in two different holes. Drilling two holes may be more economical than drilling and reaming one hole for a high-strength taper or dowel pin, and will considerably reduce deflection.

Quick Release Pins

Commercially available quick-release pins vary widely in head styles, types of locking and release mechanisms, and range of pin lengths.

In contrast to the majority of semi-permanent pin fasteners which require a "force-fit" assembly, quick-release pins are designed for a clearance fit in holes formed to nominal-diameter dimensions. Holes drilled to normal production tolerances are generally considered adequate. Quick-release pin fasteners are of two basic types: 1. Push-pull. 2. Positive locking.

Push-Pull Pins: These pins are made with either a solid or hollow shank, con-

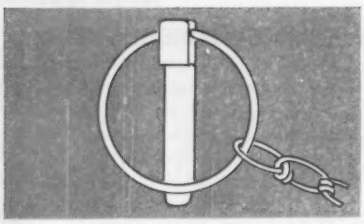
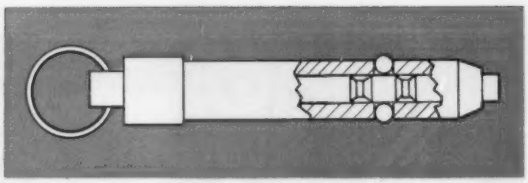


Fig. 4—Heavy-duty cotter pin. When the pin is inserted, the ring is folded down to lock the pin securely in place.

Fig. 6—Double-acting pin. Locking action is controlled by means of manually operated spring-located plunger-and-ball mechanism.



taining a detent assembly in the form of a locking lug, button, or ball backed up by some type of resilient core or plug. The detent member projects from the surface of the pin body until sufficient force is applied in assembly or removal to cause it to retract against the spring action of the resilient core and release the pin for movement.

Rated pull-out loads (force required to actuate detent) vary with manufacturers but can be regulated within limits to meet specific assembly requirements. Normal range is 10 to 30 lb, depending on pin size; however, ratings from 5 to 50 lb are possible. A value of about 10 lb is generally considered adequate for most design situations.

These pins are made 0.002 to 0.004-in. undersize to fit any standard hole drilled to nominal-diameter dimensions. From an operational viewpoint, holes up to 0.010-in. oversize are permissible; however, pull-out loads can be expected to decrease as looseness of fit increases. To facilitate assembly of the pin. hole edges should be deburred or slightly chamfered.

Primary function of these pins is to fasten parts under shear loading. Ideally, direction of load application should be at right angles to the shank of the pin. Locking mechanisms of these pins are designed to provide secure retention against accidental disassembly due to vibration or the force of pin weight, but they are not recommended for application under tension loading.

In the specification and application of push-pull types of quick-release pins in mechanical assemblies, here are some practical points to be kept in mind:

1. To prevent pins from being lost or mislaid, or from falling into the operating assembly and becoming lodged, some means of anchoring the pin near the point of application should be provided. For example, a short length of cable, chain, or wire can be employed to fasten the pull grip or handle to a main structural member, allowing sufficient slack to permit free movement of the pin in assembly and disassembly.

2. If pin assemblies are to be exposed to severe environmental conditions (temperature, moisture, etc.), consideration should be given to the possibility of jamming due to freezing or expansion of the pin and its mating parts. In some instances, pretesting of prototype assemblies under simulated operating conditions may be justified where reliability is a critical factor.

3. In rotating assemblies, pull-out load developed by the pin should be sufficient to withstand the effect of any centrifugal forces produced. Otherwise, the pin may creep out of its hole, unlocking the assembly.

4. Location of the pin assembly should permit easy pin removal by a quick pulling motion with one hand. High pull-out load requirements in cramped space can lead to problems in assembly and disassembly, and should be avoided.

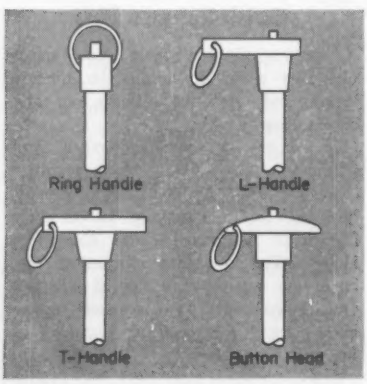


Fig. 5—Handle styles available for quick-release pins.

Positive-Locking Pins: Three types of quick-release fasteners have been developed in which the locking action is independent of insertion and removal forces: The heavy-duty cotter pin, the single-acting pin, and the double-acting pin.

As in the case of the push-pull pins, these pins are primarily suited for application under shear loading. However, some degree of tension loading usually can be tolerated without affecting the pin function.

Heavy-Duty Cotter Pin: Developed for heavy-duty fastening service in agricultural equipment, this quick-release pin, Fig. 4, employs a forged high-carbon steel body to replace the conventional split-cotter construction Locking action is provided by a tempered steel snap ring mounted to the head of the pin. In assembly, the ring folds over the end of the shaft, or similar member, in which the pin is assembled.

Single-Acting Pins: Locking action of single-acting pins is controlled by a plunger-actuated locking mechanism. In normal (locked) position, the locking element projects beyond the surface of the pin shank to provide a positive lock. Either ball or pin-type locking elements may be employed depending on the manufacturer. When the plunger is moved by means of a button or lever assembly at one end of the pin, the locking element is retracted or released to sink below or flush with the pin surface, unlocking the pin for movement in and out of the hole.

A number of head styles and release mechanisms have been developed for these pins. Conventional forms include button-head, T-handle, and L-handle designs, Fig. 5, with a pushbutton release. The button-head construction is recommended for general-purpose application and offers advantages from an appearance standpoint. The T and L-handle designs are recommended where binding in assembly is possible and may require a firm grip and twisting motion for disassembly. Pull-release types, as well as combination push-pull units, for remote operation or other special assembly requirements can also be obtained.

All of these pins are made undersize for a free fit in holes drilled to nominal-diameter dimensions.

These pins offer some amount of capacity in tension, varying with the design. Determining consideration in such applications will be either the strength in bearing of the part material in contact with the locking element or the shear strength of this element at the plane of loading, whichever is the lower.

Double-Acting Pins: A modification of the single-acting type, these pins, Fig. 6, have a bidirectional spring-located plunger. That is, movement of the plunger in either direction along its barrel will release the locking balls.

Conventional form of this pin has a pull-ring at the head end with the tip of the plunger extending beyond the other end of the pin. An intentional blow on the protruding head or tip shifts the plunger, releasing the balls and permitting the pin to be driven in or out of the hole. In addition, direct manual removal of the pin may be accomplished by means of the pull ring.

DESIGN DATA

CHAPTER 15

Small Rivets

TECHNICAL COMMITTEE
Tubular and Split Rivet Council, New York, N. Y.

FOR products made in large volume, few fasteners can match the advantages of high-speed assembly and low cost offered today by tubular and split rivets. Widely used in all types of moderately loaded joints, these rivets can be set at high rates of production on manually operated or automatic bench or floor-mounted equipment, Fig. 1.

However, while their tolerances are in line with the requirements of most high-production assembly jobs, they are not precision items like screw machine parts. Neither are they considered tension fasteners. However, compressive and shear strengths on a par with solid rivets can be attained, Fig. 2. So, in the final analysis, cost and ease of assembly are the primary basis for use of these rivets.

Riveting machines vary widely in design, size, and capabilities, but all are based on essentially the same principle of operation. The rivet is fed from a hopper to a track which deposits it, shank down, in the center of the jaws. Then, a driver descends, forcing the rivet through the jaws and onto a spring-mounted plunger. With continued downward motion, the plunger pin retracts and guides the rivet through the work until it bottoms against the lower die and is clinched. When the driver and jaws retract, the plunger pushes the rivet and work off the die in the same manner as stripper pins operate in a pressing or drawing operation.

Design of small-rivet assemblies is influenced by two major considerations: 1. The joint itself, its strength, appearance and configuration. 2. The final riveting operation, in terms of equipment capabilities and production sequence. Since the basic advantage of riveting is that it permits automatic feeding of the fastener to assure high-production rates and low assembly costs, the product design must be integrated with the riveting equipment and the production program if optimum results are to be obtained.

Design Recommendations

1. **Select the right rivet.** Basic types are covered in Table 1. Standard rivets should be used whenever possible. The tooling to produce small rivets is quite economical, making it tempting to specify slightly different diameters or lengths than are available as manufacturers' standards.

But there are innumerable advantages to standard rivets, not the least of which is their availability from stock. The Tubular and Split Rivet Coucil has issued standards on semitubular rivets.

However, special rivets should be considered if they can improve product performance, function, or assembly. For example, shoulder rivets are sometimes desirable, since they perform a spacing function that otherwise would require another part. Special shanks, heads, materials, and finishes also can be advantageous in certain design situations.

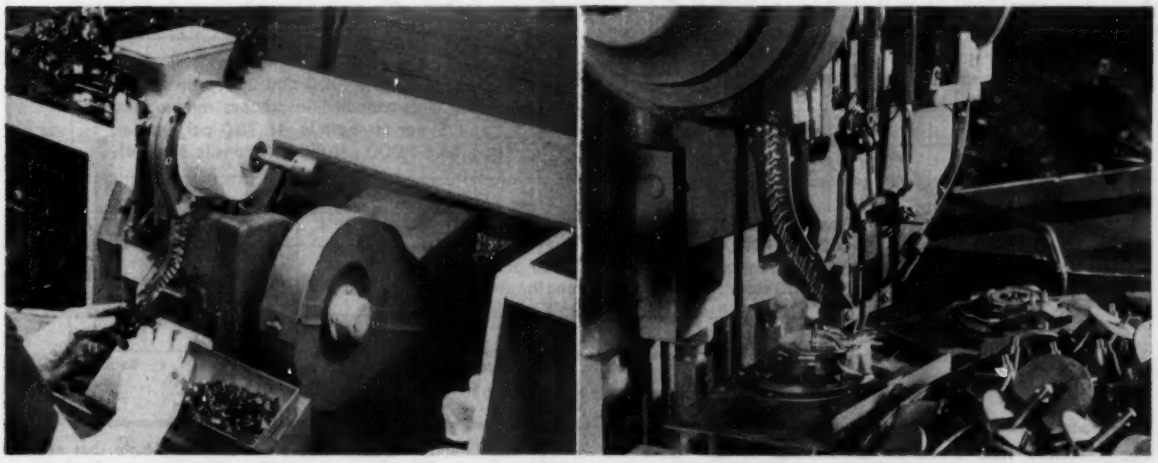


Fig. 1—Typical rivet-setting machines. Single-spindle riveter at left is combined with a conveyor line which transfer assemblies to other stations. Double-spindle machine at right is integrated with rotary table to obtain fully automatic operation.

2. **Standardize on rivet sizes and types.** This practice minimizes rivet and tooling inventory. Seldom are production requirements so varied as to necessitate many different sizes and types of rivets. Usually, with little extra effort, dimensions can be standardized, investment in tooling lessened, and problems of stocking and coding rivets eliminated.

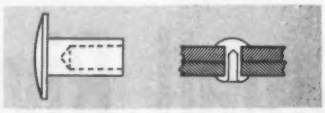
3. **Use rivets to perform multiple functions.** A rivet often may be used both as a fastener and a functional component. For example, it may serve as a stop, a stud, a pivot, an electrical contact, or, when formed with a specific design, a means of product identification.

4. **Determine proper rivet diameter and length.** Rivet manufacturers list the recommended hole clearance for each diameter of rivet they produce. They also list the clinch allowance needed. The principal dimensional considerations are shown in Fig. 3. If the rivet diameter is too small in relation to hole diameter, joint quality may be impaired. If the rivet is too large, there is interference.

Length is critical also. An inadequate clinch allowance, which is a function of the rivet length, results in a poor set. Too long a rivet will buckle in assembly or cause tooling to wear excessively.

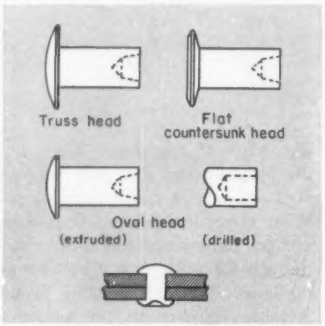
The proper length allowance for a clinch on a full tubular or bifurcated rivet normally is around 100 per cent of shank diameter. For a semitubular rivet, it is between 50 and 70 per cent of the shank diameter.

Table 1—Basic Types of Small Rivets



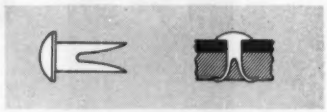
Tubular

Has a drilled shank with hole depth more than 112 per cent of mean shank diameter. Can be used to punch its own hole in fabric, some plastic sheet, and other soft materials, eliminating a preliminary punching or drilling operation. Shear strength is less than for a semitubular rivet.



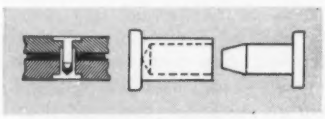
Semitubular

Most widely used type of small rivet. Depth of hole in rivet, measured along wall, does not exceed 112 per cent of mean shank diameter. Hole may be extruded or drilled, depending on manufacturer and/or rivet size. When properly specified and set in a prepared hole, this rivet becomes essentially a solid member since hole depth is just enough to form clinch. Used whenever maximum shear strength is needed. Strength in shear or compression is comparable to solid rivet. Dimensions have been standardized by Tubular and Split Rivet Council: Nominal body diameters, 0.061 to 0.310 in.; corresponding minimum lengths, 1/16 to ¼ in.



Bifurcated (Split)

Rivet body is sawed or punched to produce a pronged shank that punches its own hole through fiber, wood, or plastic. With a few exceptions, punched shanks are more suitable than sawed shanks for piercing operations on nonmetallic materials. Sawed or broached types serve for applications in nonmetallic materials such as leather or fabric. Sawing or broaching does not distort leg as much as punching does, but punching cold works the material and makes it tougher. However, size of rivet may affect this general rule.



Compression

Consists of two elements: Solid or blank rivet and deep-drilled tubular member. Pressed together, these form an interference fit. Because heads of both members can be produced to close tolerances, these rivets are commonly used when appearance from both sides of the work must be uniform and heads must be flush to prevent accumulation of dirt or waste. Can be used in wood, brittle plastics, or other materials with little danger of splitting during setting.

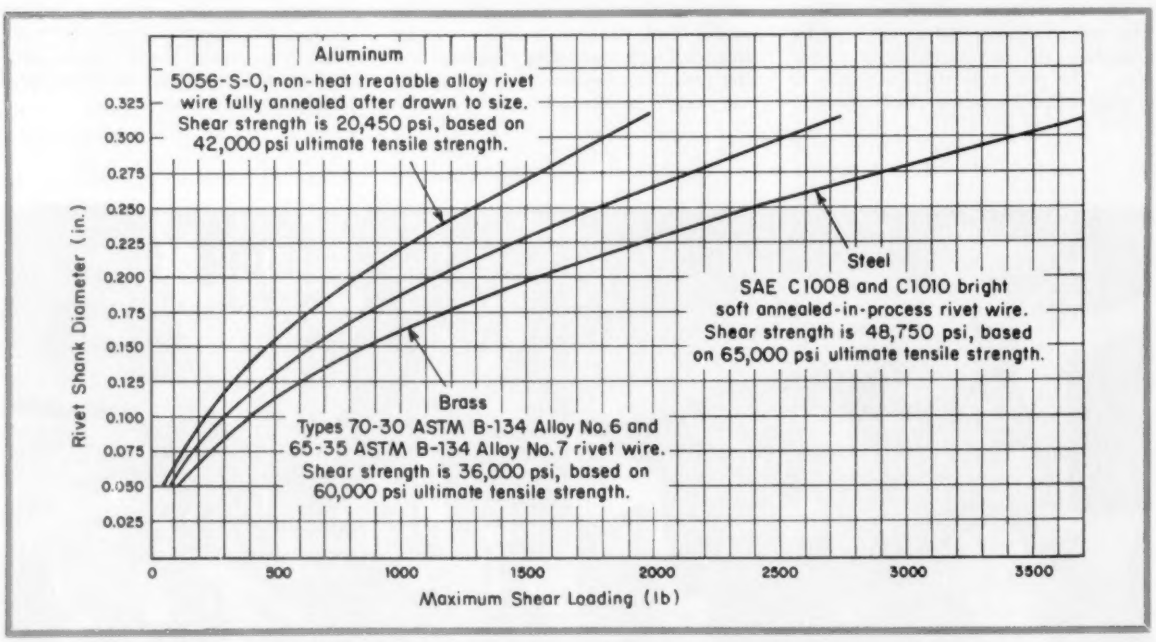


Fig. 2—Shead load limits for semitubular rivets. Data are based on minimum rivet body diameter and apply only to joints in which the edge distance and hole spacing are great enough to prevent failure in the assembly that is being joined. They do not hold for tu' ular rivets which have a hole that extends into the load bearing area. Also they do not take into account the offset that results because the shank is not expanded to fill the hole.

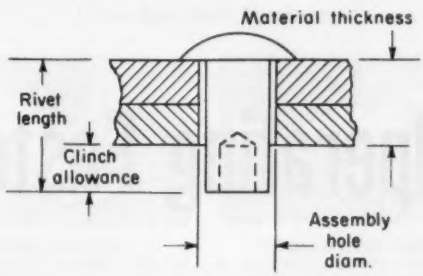


Fig. 3—Dimensional data needed for small rivet specifications.

5. **Match fastener material to joint requirements.** Rivets are made in a wide range of materials, including steels in low carbon through alloy grades, Monel, aluminum, brass, precious metals, and others. Most popular, and least expensive, material is low-carbon steel, about a 1010 classification. This is stocked by rivet manufacturers as are brass and aluminum wires. Rivets of certain alloys or precious metals generally are obtained only on special order.

6. **Use proper type of clinch.** There are two basic types of clinches for tubular and semitubular rivets: 1. Roll set. 2. Star set.

The roll-set clinch forms a rolled edge around the end of the rivet shank that clinches onto the work. A star-set clinch cuts the wall of the shank and sets the rivet in the form of a star. The latter is recommended when extreme variations in material thickness commonly occur. However, it is less secure than a roll-set clinch which is usually specified where full strength of the rivet must be developed.

Bifurcated rivets are usually set against a solid form that curls back the prongs and presses them into the work to provide a smooth clinch. When a washer or cap is employed, it is held in a solid tip, and the tubular or bifurcated fastener is driven through the work and into the cap and clinched within it.

Compression rivets, on the other hand, are not set as such, but are pressed together to form a tight fit. This is done by feeding the male member from the top arm of the riveting machine while holding the bottom or female half against a flat anvil.

7. **Consider product-finish requirements early.** Rivets can be plated, anodized, painted, or treated with various chemical finishes. But if the assembly is to be finished after the joint is made, there is little point in specifying a special finish on the rivets other than one that provides a better base for bonding or aids identification during assembly. On the other hand, components may be finished before riveting is performed. Then a finished rivet may be necessary.

8. **Select rivet to minimize production operations.** If semitubular rivets are preferred, a punched or drilled hole often is provided. But if parts are nonmetallic or made of thin-gage sheet, a full tubular rivet will eliminate the need to predrill.

Of course, semi-tubular rivets also can punch their own holes in some thin gauge or nonmetallic stock. In fact, this practice has considerable promise.

Dimpling or countersinking generally are not necessary with tubular or semitubular rivets, except when it is necessary to provide a flush joint.

9. **Make joints symmetrical.** If rivets can be located equal distances from a common center or spaced symmetrically, the assembly usually can be made more quickly and will lend itself far better to automatic fixturing or indexing.

10. **Provide adequate joint access.** Components must be fed to the rivet-setting machine. The throat depth of the machine must be considered when establishing clearances. If the distance between the rivet and adjacent surfaces is too small, there will be interference when the work is positioned or the machine is cycled. The diameter of the setting tool, which is made a few thousandths over the rivet shank diameter, and the area of the jaws when opened, also are critical assembly dimensions.

11. **Analyze load characteristics.** A semitubular rivet is strongest in shear, weaker in tension. Therefore, the joint should be designed accordingly.

12. **Form rivet clinch against a solid flat surface.** Obviously any irregularity under the clinch subtracts from the fastening quality of the rivet or deforms the clinch. Usually this condition can be rectified by such means as machining, relocating the rivet hole, or by adding a washer. If the base material is resilient or ductile, a washer may be added and the clinch formed against it. A rivet can, however, be set against a curved or angular surface, the former practice being very common in the metal furniture industry.

If a choice is available, clinch the rivet against the heavier component when a second section is to be joined. Reverse that procedure if materials are nonmetallic and the thinner part is the more rigid and stronger.

13. **Check assembly progression.** Construct the sequence of the assembly to make certain that the last rivet to be set is not blocked by previously attached members.

14. **Provide proper edge distance and spacing.** For tubular or split rivets, the recommended edge distance is twice the shank diameter of the rivet. Rivet spacing or pitch should be three times the shank diameter. These minima are based on Federal standards for all small rivets and are related to joint strength. When rivets are machine set, tool clearances generally require more liberal allowances.

15. **Test the assembly under simulated service conditions.** In the final analysis, this is the only way to get a realistic picture of design performance.

DESIGN DATA

CHAPTER

16

Quick-Operating Fasteners

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HOW QUICK is quick? For quick operating fasteners, at least, the term cannot be defined by holding a stop watch on the access operation. There are fasteners so-called that can be unlocked in fractions of a second, while others may require several seconds. Both qualify for inclusion in the species "quick-operating."

It is far more practical to define the term from the standpoint of application. A quick-operating fastener, then, finds its logical use where repeated access will be necessary. Just how much time should be required for fastener operation is a question that will have to be resolved separately for each specific situation.

Sometimes, however, there is a temptation to over-emphasize the access-time element to such an extent that good design practice may suffer. However, simplicity of fastener design, strength of construction, smoothness of operation, and ease of installation are also important.

Except in rare cases, it is doubtful that a difference of 2 to 4 seconds in the time required for actuating a fastening device will be a vital matter to the operator, especially when only one or two fasteners are used on a door or panel. When eight or ten fasteners are used on a door, the time necessary to operate each becomes more significant. However, other factors must be considered along with the time cycle of the fastener to evaluate properly the speed of access through a panel.

For example, a quick-release, quarter-turn, countersunk-head fastener with Phillips recess may not really offer fast access to an operator who does not have the required screwdriver close at hand. The same fastener, in the face of material thickness variations and misalignment conditions might be difficult or slow to actuate because, by its nature, it depends on uniform material thicknesses and proper alignment for smooth, fast operation. Conversely, a fastener designed to open with several turns might offer quicker access (and less trouble) because it is designed to compensate for misalignment and thickness variations.

Designing into an Assembly

The problem of selecting and using a quick-operating fastener can be broken down into four general considerations:

1. Consider fasteners early. Design the package with available fasteners in mind. Although it is not always possible to design an assembly around a specific fastener, try to avoid creating an envelope that will require a fastener which hasn't yet been invented.

Today, there is so great a variety of stock, quick-operating fasteners available that almost any conceivable application can be served off the shelf. However, this holds only when the fastening problem is considered early as an integral part of the package design. A door, frame, panel, plate, or lip that no standard fastener will fit can be an expensive headache when discovered at the last minute.

The availability of numerous types of stock fasteners is a mixed blessing, since it raises the possibility of combining a variety of quick-operating devices on the same closure. In striving for simplicity of design, aim for a product package that, wherever possible, will use the same type of fastener throughout.

2. Don't overspecify. The less demanded of a fastener, the wider the field for selection.

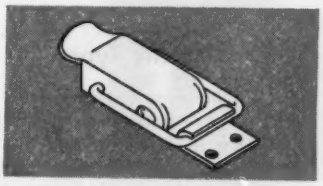
Specification factors vary in individual importance. Begin with a checklist to compare specific requirements as a preliminary step to selection. The accompanying list is suggested as a general starting point, but may have to be modified for specific situations. Attempt to eliminate all unnecessary considerations; overspecifying tends to limit selection and add to cost and installation problems.

Qualities desired in certain fasteners are often mutually exclusive; that is, if one advantage is present it sometimes preclude another. Often, the more quickly a fastener can be operated, the more exacting the installation becomes from the standpoint of holding close tolerances. Thus, extreme speed of access might be obtained at the expense of low installation costs.

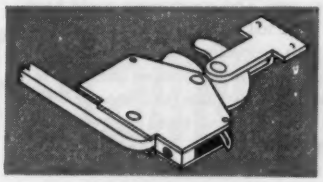
3. Match costs to requirements. An infinite range of devices is manufactured which vary in size, complexity, and cost. A half-penny machine screw could conceivably serve as a quick-operating device where only one is needed to hold a panel that must be opened once a year. Conversely, where a great number of the points enumerated in the checklist apply to the application, the fastener may cost several dollars, but, nevertheless, it can probably be obtained from some manufacturer's stock—invariably the least expensive way to procure a fastener.

The actual price of the fastener is only a small part of the total fastening cost. Examine the cost of installing the device; it is usually considerably more than the price of the part. The magnitude of these costs could vary not only with the application but with the type of operation involved. To an aircraft company, accustomed to working to close tolerances, a closely controlled installation is routine. To another type of industry, working to such unaccustomed tolerances might result in a high scrap loss, an unsatisfactory installation, or increased costs in raw materials and quality control to maintain uniform sheet thickness, eliminate bow and warp, and control hole size, edge

Lever-Actuated Fasteners

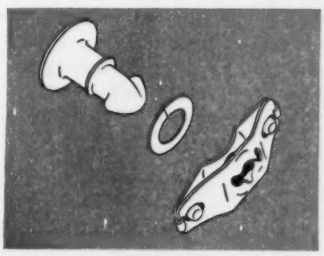


DRAW-PULL CATCH
A spring or *drawhook assembly*, with *operating lever* engaging a *keeper* or striker. Will handle edge-to-edge applications. Good leverage for pulling parts together. Good resistance to shock and vibration. No parts inside assembly.

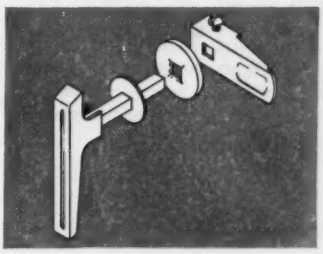


CAM-ACTION FASTENER
A *cam assembly*, operated by a *lever* or handle, engaging a *keeper*. Quick disconnect (positive travel can be used to break or set up a circuit). Good resistance to shock, pull-out and vibration. Actuating lever can serve as carrying handle for subassembly.

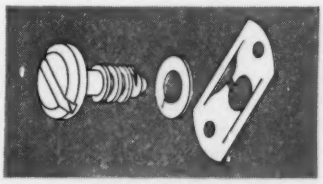
Turn-Operated Fasteners



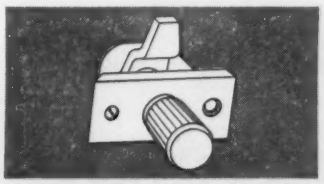
QUARTER-TURN or AIRCRAFT TYPE
A *stud*, locked into the door or cover panel by a *retainer* and engaging into a *receptacle* on the frame or chassis. Very fast actuation. Good resistance to vibration and shock. Light weight. Conserves space. Variety of head styles available.



PAWL FASTENER
A *shaft with knob*, a *retaining device*, and a *pawl* which catches against the door frame or keeper. Quarter-turn operated. Easily installed. Can be set to fit varying door or frame thickness.

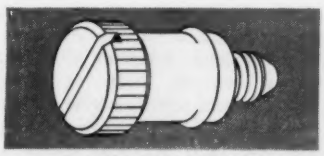


SCREW FASTENER
A *screw assembly* with heavy square thread, a *retainer* and a *receptacle*. Usually actuated with 2 to 3 turns. Good tolerance for varying material thickness and misaligned parts. Easy to install. High strength. High resistance to vibration, shock and fatigue. Not fouled by paint. Variety of head styles.

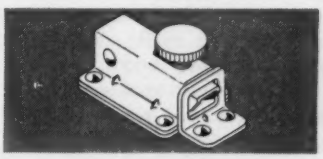


ADJUSTABLE PAWL FASTENER
A single unit with *spring-loaded pawl* travelling along a *threaded shaft* set in a *housing* which is riveted, screwed or welded to the door. Quarter-turn operated. Preassembled for quick installation. Fits any door or frame thickness (grip range can be changed by turning the knob). Additional turning will apply any desired pressure to door. Requires no striker. Excellent for gasketed doors.

Slide-Action Fasteners



STANDOFF THUMB SCREW
A polished *screw* and a *retaining device*, which captivates the screw into a standoff. Widely accepted for use on electronic equipment. Attractive appearance. Can be fully disengaged without backing panel off door. Will operate in a tapped hole. Screw retracts completely for providing zero inside projection where panels move laterally with respect to each other.



SLIDING LATCH
A *sliding pawl* engaging in a *keeper*. Variations include use of a tightening knob. All parts on outside of assembly. Good general strength. Some types can be used as an automatic-locking drop-latch when used at the bottom of a top-hinged door.

DESIGN CHECK LIST

1. How urgent is the need for split-second access?
2. To what extent will the fastener be subjected to:

   Impact? Loading in tension?

   Vibration? Loading in torque?

   Fatigue? Corrosion?

   Loading in shear?
3. Is conservation of space on the inside or outside (or both) essential?
4. Must the fastener be capable of operation by personnel wearing heavy gloves? (As in extremely cold climates.)
5. Will it be subjected to a wide range of heat or cold?
6. Must it pull up against the frame to compress a gasket or form a dust seal?
7. Must it resist tampering by unauthorized personnel?
8. Is weight a problem?
9. Should protruding knobs or handles (that might catch on clothing) be avoided?
10. Must it be hand operated?
11. Are metallurgical qualities a necessary consideration? (Galvanic reaction, magnetic properties, heat transfer, etc.)
12. Must it tolerate misalignment of panels and components during assembly?
13. Will the panels become deformed (or misaligned) during service life?
14. Should a special keeper, striker plate, or receptacle be avoided?
15. Are there Military Specifications to be met?
16. Will the fastener be installed by skilled or unskilled workers?
17. Should it be installed without special tools?
18. Must visual inspection indicate whether or not the door is locked?
19. What is the estimated service life of the assembly?
20. Should installation present no problem of damage to painted surfaces?
21. Should the fastener be purchased and installed as a preassembled unit?
22. Alternately, should different components be installed separately at different stages of assembly?

location, and center distance.

Think, too, about the impact of the fastener on the eventual user of the product. Many expensive and well made products have been severely prejudiced because someone saved a few cents on the purchase price of a fastener.

4. Ask for samples. Fastener manufacturers, for a very logical reason, often avoid exact figures on strength data in

their catalogs. The values given will almost always vary with the individual application, according to the materials and conditions in which the fastener will be used. One value might be assigned to a fastener for resistance to vibration, another for shock, and still others for shear and tension; however, these figures might not apply when the same fastener is subjected to a combination of such forces. Only in actual application can a potential combination of forces be simulated and tested. The manufacturer will usually furnish samples of any stock quick-operating fastener for test. The results found by testing under actual application conditions will be far more reliable than any generalized laboratory test data.

MIL Specification

Military specifications serve a very useful purpose, but they pose one serious disadvantage. The government could hardly be expected to undertake the task of continually inspecting, testing, and writing specifications for every new quick-operating fastener that hits the market. This means that only a small percentage of fasteners today have Military Specification numbers, limiting the designer's choice of fasteners.

Most MIL Spec fasteners were developed 15 to 20 years ago, and later were covered by the now existing specifications; thus, many excellent, often superior, devices (particularly those of later design) are apparently ruled out. Fortunately, project approval is usually granted upon request for any quality fastener a manufacturer wishes to use.

Fastener Types

Quick operating fasteners fall into several general categories, but all have one feature in common—captivity. The precept that no loose parts should be lying around after a door has been opened gets an argument from nobody.

The families of fasteners generally considered to fall in the quick-operating category are summarized in the table on the preceding page.

DESIGN DATA

CHAPTER 17

Retaining Rings

RETAINING rings, or snap rings, are a method of providing a removable shoulder to accurately locate, retain, or lock components on shafts and in bores and housings. They are easily installed and removed, and since they are usually made of spring steel, retaining rings have a high shear strength and impact capacity. In addition to fastening and positioning, a number of rings are designed for taking up end play caused by accumulated tolerances or wear in the parts being retained. In general, these devices can be placed into two categories: Stamped retaining rings, and bent-wire rings. The first discussion in this chapter concerns the stamped retaining rings, followed by a section devoted to wire-formed rings.

Stamped Retaining Rings

HUGO WURZEL

Chief Design Engineer, Truarc Retaining Rings Div., Waldes Kohinoor Inc., Long Island City, N. Y.

In contrast to wire-formed rings, with their uniform cross-sectional area, stamped retaining rings have a tapered radial width which decreases symmetrically from the center section to the free ends. The tapered construction permits the rings to remain circular when they are expanded for assembly over a shaft, or contracted for insertion into a bore or housing. This constant circularity assures maximum contact surface with the bottom of the groove.

Stamped retaining rings can be classified into three groups: Axially assembled rings, radially assembled rings, and self-locking rings which do not require grooves. Axially assembled rings slip over the ends of shafts or down into bores, while radially assembled rings have side openings which may be snapped directly into grooves on a shaft.

Most axially assembled rings have holes in the lugs at the free ends. Special retaining-ring pliers fit into these holes and expand or contract the rings for installation or removal. Radially assembled rings are installed and removed with a screwdriver or other simple hand tool. Several varieties of self-locking rings, which do not require grooves, are available for assemblies in which the fastener need not absorb any sizable thrust, but instead serves mainly as a positioning and locking device. Commonly used types of stamped retaining rings are illustrated and compared in Table 1.

Most stamped retaining rings are manufactured of high-carbon spring steel and are supplied with an oil-dipped finish. A number of other protective finishes, including cadmium, zinc, and chemical conversion coatings, are available for special applications. Rings made of aluminum, beryllium copper, phosphor bronze, and corrosion-resistant stainless steels are available for special assembly requirements from most manufacturers. These metals normally are used without any additional protective finish

Table 2 compares the maximum allowable working stresses, s, of the more common ring materials during expansion or contraction before the ring exceeds the elastic limit of the material and takes a permanent set.

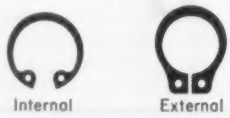
Designing Retaining Rings Into An Assembly

Size Selection: Standard rings are available in sizes ranging from 0.040 to 10 in. in diameter. Rings as large as 39 in. in diameter have been manufactured for special applications. In selecting specific ring types for individual assemblies, the designer should consider both ring and groove load capacities. The lower of the two will be the limiting factor in the assembly. The ultimate thrust load to which a ring may be subjected depends upon the ring's shear resistance; ultimate groove thrust load capacity is a factor of compressive resistance. Formulas for calculating allowable ring and groove loads are listed in Table 3.

Configuration of Retained Part: For optimum ring performance, the abutting face of the retained part should be straight and have sharp corners. Loads will then be transmitted as close as possible to the groove wall, utilizing the full

Table 1—Types of Stamped Retaining Rings

Axially Assembled Rings Used in Grooves

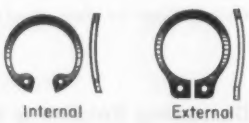


BASIC TYPES

Designed for axial assembly. Internal ring is compressed for insertion into bore or housing, external ring expanded for assembly over shaft. Both rings seat in deep grooves and are secure against heavy thrust loads and high rotational speeds. External rings for shafts over 4 in. diam. are supplied with special lugs to maintain ring balance during rotation.

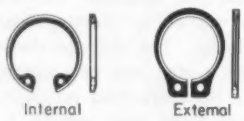
INVERTED RINGS

Same tapered construction as basic types, with lugs inverted to abut bottom of groove. Section height increased to provide higher shoulder, uniformly concentric with housing or shaft. Rings provide better clearance, more attractive appearance than basic types. Can accommodate parts with curved abutting surfaces, large corner radii or chamfers. Because of lug design, rings have less contact surface with groove wall than basic types, somewhat lower thrust load capacity.



BOWED RINGS

For assemblies in which accumulated tolerances cause objectionable end play between ring and retained part. Bowed construction permits rings to provide resilient end-play take-up in axial direction while maintaining tight grip against groove bottom. Used widely to preload bearings, provide spring tension on adjustment devices and prevent rattle in machine linkages. Useful also for salvaging assemblies designed originally for flat rings where groove has been cut too wide.



BEVELED RINGS

Designed for rigid end-play take-up. Rings have a 15-deg bevel on groove-engaging edge and are installed in grooves having corresponding bevel on load-bearing wall. Ring acts as a wedge between retained part and groove wall, seating deeper in the groove to compensate automatically for tolerances or wear. Used widely in applications where a tight seal is critical.

Radially Assembled Rings Used in Grooves

CRESCENT RING

Has a tapered section similar to the basic axial types. Remains circular after installation on a shaft and provides a tight grip against the groove bottom. Because of narrow section height and uniformly circular shoulder, used widely in assemblies where clearance is limited.

E-RINGS

Provides a large bearing shoulder on small-diameter shafts and often is used as a spring retainer. Three heavy prongs, spaced approximately 120 deg apart, provide contact surface with groove bottom. Seated in deep groove for increased thrust capacity. Bowed E-rings are used for providing resilient end-play take-up in an assembly.

REINFORCED E-RING

Provides approximately 5 times greater gripping power and 50 per cent higher rotational speed limits than conventional E-rings. Heavy web section and tapered bending arms develop substantially greater spring pressure with no increase in permanent set.

LOCKING PRONG RING

Derives its name from two prongs which grip shaft and prevent ring from being forced from groove. To be removed, ring must be flattened so that prongs clear groove. Fastener has relatively high thrust load capacity and may be used as shoulder against rotating parts. Bowed construction provides resilient end-play take-up and permits ring to function as spring as well as shoulder.

INTERLOCKING RING

Balanced two-part ring designed to withstand high rotational speeds, heavy thrust loads. Identical semicircular halves are held together by interlocking prongs at free ends. Forms high circular shoulder uniformly concentric with shaft. Secure against relative rotation between retained parts. Attractive appearance makes fastener especially suitable for exposed applications.

Self-Locking Rings Which Do Not Require Grooves

CIRCULAR EXTERNAL RINGS

Push-on type fasteners with inclined prongs which bend from their initial position to grip the shaft. Ring at left has arched rim for increased strength and thrust load capacity; extra-long prongs accommodate wide shaft tolerances. Ring at right has flat rim, shorter locking prongs, smaller OD. Recommended for assemblies where flat contact surface with retained part is required or clearance dimensions are critical.

CIRCULAR INTERNAL RING

Designed for use in bores and housings. Functions in same manner as external types except that locking prongs are on outside of rim. Like other self-locking rings, useful for taking up end-play caused by accumulated tolerances in retained parts.

GRIP RING

Exerts a frictional hold against axial displacement from either direction. Tapered section permits ring to remain circular after expansion and assure maximum contact surface with shaft. Ring is substantially thicker than basic external type and has larger section for increased spring pressure and shoulder height. Fastener is adjustable on shaft, does not mar surface and is reusable following disassembly.

TRIANGULAR RETAINER

Provides larger shoulder than circular push-on types and has greater gripping strength. Dished body holds retained part under spring pressure, eliminating need for bowed washers and other tensioning devices. In larger sizes, inclined prongs are ribbed for increased stiffness and holding power.

Table 2—Maximum Working Stress for Various Ring Materials

Material	Max Working Stress, s (psi)
Carbon spring steel (SAE 1065-1090)	250,000
Stainless steel (AISI Type 420)	250,000
Stainless steel (Armco PH 15-7 Mo)	250,000
Beryllium copper (Berylco 25)	200,000
Phosphor bronze (Grade D, No. 10 Hard)	110,000
Aluminum (Alclad 7075-T6)	70,000

Table 3—Ring and Groove Load Limits

Static thrust load on ring	$P_r = k_r \dfrac{St\pi s_s}{F}$
Static thrust load on groove	$P_g = k_g \dfrac{Sd\pi s_y}{F}$
Impact loading on ring	$I_r = \dfrac{P_r t}{2}$
Impact loading on groove	$I_g = \dfrac{P_g d}{2}$
Vibration loading on ring	$wa \leqq 540\,P_r$
Vibration loading on groove	$wa \leqq 400\,P_g$
Harmonic oscillation for ring or groove	$a \cong 40\,\rho f^2$
Allowable thrust load on ring when retained part rotates relative to ring	$P_{rr} \leqq \dfrac{sth^2}{\mu 18S}$
Elastic deformation (temporary displacement of retained part under load)	$\delta = \dfrac{T}{Ed}$

Nomenclature

a = Acceleration of parts, in./sec^2
d = Groove depth, in.
E = Modulus of elasticity of groove material, psi
F = Safety factor, varies with ring design and material. Use 4 for static thrust load on ring (P_r) for basic steel internal and external rings. Use 2 for static thrust load on groove (P_g).
f = Frequency, cps
h = Section height of the largest section of ring, in.
I_g = Allowable impact load on groove, in.-lb
I_r = Allowable impact load on ring, in.-lb
k_g = Constant which varies with groove type (Table 5)
k_r = Constant which varies with ring type (Table 5)
P_g = Allowable static thrust load on groove, lb
P_r = Allowable static thrust load on ring, lb
P_{rr} = Allowable rotating thrust load on ring exerted by adjacent part, lb
S = Shaft or housing diameter, in.
s = Maximum allowable working stress of ring under maximum expansion or contraction before ring exceeds elastic limit and takes a permanent set (Table 2), psi
s_s = Ultimate shear strength of ring material, psi
s_y = Tensile yield strength of groove material, psi
T = Acting load, lb
t = Ring thickness, in.
w = Weight of retained parts, lb
δ = Deflection, in.
μ = Coefficient of friction (for dry parts = 1.15 − 1.20)
ρ = Amplitude, in.

height of the ring to resist shearing and provide maximum uniform compression loading for the groove wall. If the abutting face is curved and the resultant of the forces is transmitted from the part to the ring at a distance from the groove corners, the ring will tend to dish under the forces. The groove wall will then not be loaded uniformly, reducing the ultimate thrust capacity.

Retaining-ring manufacturers specify the maximum allowable corner radii and chamfers for each ring size with corresponding static thrust capacities. If these thrust capacities are insufficient for the assembly, a rigid, square-cornered flat washer may be inserted between the ring and the retained part. If the assembly will be subject to dynamic loading conditions and the retained part has a corner radius or chamfer, the washer is mandatory for optimum ring performance.

Clearance: There should be a sufficient design clearance allowed in order to assemble and disassemble the ring with minimum effort. Clearance must also be considered in relation to subsequent assembly of adjacent parts. Selection of ring types to be used affects clearance requirements. A Crescent ring, for example, has a substantially lower shoulder than an E-ring and for many assemblies supplies a sufficiently large bearing surface. Rings with inverted lugs form a uniformly circular protruding shoulder and similarly provide more clearance than the basic internal and external types.

Edge Margin: The shoulder between the outer groove wall and the end of the shaft or housing, exclusive of any radius or chamfer, is known as the edge margin. This edge margin must be sufficiently wide to permit cutting the groove without damage to the outer groove wall and wide enough for the groove wall to withstand the thrust loads which will be exerted against it. Minimum edge margin is generally considered to be three times the nominal groove depth specified for any particular ring.

Axial or Radial Rings: Configuration of the retained parts and available clearance should be considered before selecting a ring for axial or radial assembly. The axial types generally have higher rotational speed limits and present a neater appearance. Radially installed rings are usually easier to install and remove, and no special tools are required. Tool clearance required should be considered in either case

Tolerance Take-up: Tolerances in ring thickness, groove location, and the dimensions of the components being retained may add up to cause objectionable end play between the ring and the retained part in a retaining-ring design application. Where this occurs, consider the use of bowed or beveled rings. Bowed rings are available for resilient end-play take-up, beveled rings for rigid take-up. Self-locking rings, which may be positioned at any point on a shaft or in a housing, also may be used to compensate for accumulated tolerances.

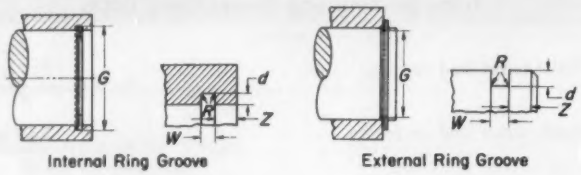


Fig. 1—Grooves for basic and inverted type internal and external rings.

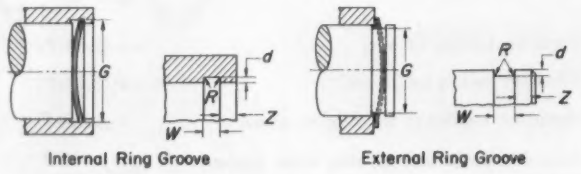


Fig. 2—Bowed-ring grooves.

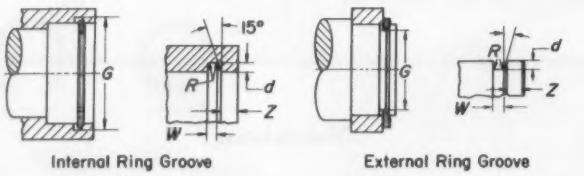


Fig. 3—Beveled-ring grooves.

These dimensions are critical for retaining-ring grooves and usually are specified by the ring manufacturer, together with maximum allowable tolerances.

Groove diameter, *G*
Groove width, *W*
Nominal groove depth, *d*
Maximum bottom radii, *R*
Edge margin, Z

Another specified dimension is the Total Indicator Reading (TIR), which is the maximum allowable deviation of concentricity between the groove and the shaft or housing.

Retaining-Ring Grooves

The function and characteristics of retaining ring grooves differ according to ring types. The groove for basic and inverted type rings, Fig. 1, is used for both internal and external rings. Self-locking rings are generally used without grooves; however, a shallow groove is sometimes desirable for certain applications to increase the ring's thrust capacity and resistance to vibration. The groove is similar in character to the grooves for basic and inverted types.

Grooves for flat rings must be straight and should have sharp corners at the top. Corner radii at the bottom are recommended within limits to facilitate groove cutting and reduce stress concentrations. Grooves which are to be loaded unidirectionally may have increased groove widths, but the location of the loaded groove wall should be calculated carefully to obtain minimum end-play between the ring and the face of the retained part. If cyclic loading is present, both groove walls must be located accurately.

Grooves for bowed rings, Fig. 2, are similar to those for the basic and inverted types. The groove is cut wider, however, to permit the ring to provide a maximum of resilient end-play take-up.

Table 4—Conversion Factors for Various Groove Materials

Groove Material	Tensile Yield Strength, s_y (psi)	Conversion Factor
Hardened Steel (Rc-40)	150,000	3.3
Hardened Steel (Rc-50)	200,000	4.45
Aluminum (2024-T4)	40,000	0.89
Brass (Naval)	30,000	0.66
Other		$s_y/45{,}000$

Table 5—Values for k_r and k_s

Ring Type	k_r	k_s
Basic and bowed internal and external rings	1.0	1.0
Inverted internal, external rings	0.67	0.5
E-rings (including bowed and reinforced types)	0.33	0.33
Crescent rings	0.5	0.5
Interlocking rings	0.75	0.75
Beveled internal, external rings	1.0	0.5

The groove must be sufficiently wide to accommodate the bow height of the ring within its take-up capacity.

Location of grooves for beveled rings is very important for these rings to eliminate end-play. Beveled ring grooves, Fig. 3, have a beveled wall matching the bevel of the ring. The standard bevel angle is 15 deg. In some cases, however, where friction between the ring and groove wall is reduced—as would happen when oil is used—the angle is made smaller to remain within the angle of repose. The bevel works in conjunction with the ring's spring properties, permitting internal rings used in bores and housings to expand in the groove and external rings, used on shafts, to contract in the groove. This expansion or contraction brings the ring into close contact with the retained part, automatically compensating for tolerances and providing a rigid assembly free of end-play.

Radially-applied-ring grooves may be cut much deeper than those used for axially assembled rings, since radial rings need not be spread over the shaft before entering the groove. This increase in groove depth provides considerable thrust load capacity for the assembly, despite the fact that the rings, because of their shape, do not have 100 per cent contact with the groove wall.

Groove Materials: Since the strength of a ring assembly depends not only on the ring but on the strength of the material in which the groove is cut, it is important to select the proper material for the required loading condition. The formulas for calculating groove load capacity given in Table 3 are based upon a shaft or housing material of cold rolled steel with a tensile yield strength of 45,000 psi. When other materials are used, the allowable thrust load of the groove should be multiplied by the conversion factor shown in Table 4.

As indicated earlier, if the allowable thrust load of the groove is less than the allowable thrust load of the ring, the groove load capacity must be considered the limiting factor in the assembly. For this reason, any substitution of materials in which grooves are machined should be checked against the original load-capacity requirements for the assembly.

Wire-Formed Retaining Rings

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THE wire-formed retaining ring is a split ring formed and cut from spring wire of uniform sectional size and shape. The wire is cold drawn or rolled into shape from a continuous coil or bar. Then the gap ends are cut into various configurations for ease of application and removal.

Rings are available in many cross-sectional shapes, Fig. 1, but the most commonly used are the rectangular and circular, or round, cross sections.

Rectangular-section rings are made for internal or external applications, Table 1. Round section rings are for external use on shafts only. These rings, which fit into radiused grooves, are used where the expected load is light.

Ring assembly and disassembly tools range from a screw driver to automatic spiral-type tools, depending on the ring application. Special wire-formed rings can be obtained with holes in the gap ends.

An important wire-ring assembly advantage is that it does not matter which side of the ring bears against the groove wall under load. Some types of retaining rings must be oriented in assembly for best results.

The outstanding differences between wire-formed and stamped retaining rings are: 1. Cross-sectional thickness of comparable rings, 2. Relation of applied forces to material grain structure, 3. Distribution of thrust forces, 4. Assembly and removal requirements.

Wire-formed rings are originally formed into a pure circular shape. This means that when expanded they assume a noncircular shape with most of the bending occurring at a point opposite the gap. However, the strains which could cause set and possible fracture are always perpendicular to the grain structure of the material. Also, wire-ring thrust load is uniformly distributed to the load-bearing shoulder of the groove because of the ring's uniform cross section.

Spring steel (SAE 1060 to 1090) with a hardness range of Rockwell C 42-53 is generally considered the standard material for wire-formed retaining rings. However, stainless steel, brass, phosphorous bronze, aluminum and other materials are available. These rings are usually supplied with an oil dipped coating. Cadmium, zinc, nickel, phosphate, Parkerize, Dulite and various color coatings can also be obtained.

Designing Assemblies

Size Selection: Wire-formed rings are available for shafts and housings in the diameter range from ⅛ to 8 in. Rings up to 8 in. have been designed for use with standard SAE bearings, but other ring forms and sizes are possible.

The controlling factor in size selection is the thrust capacity of the ring. Wire-formed retaining rings, because of their configuration, usually do not fail in shear. Under an increasing load, the ring deflects and finally jumps out of the groove.

The resistance of the ring to this type of failure can be increased by increasing the ring width (section height measured in plane of diameter). Wider rings have more resistance to expansion forces which would work the ring out of the groove.

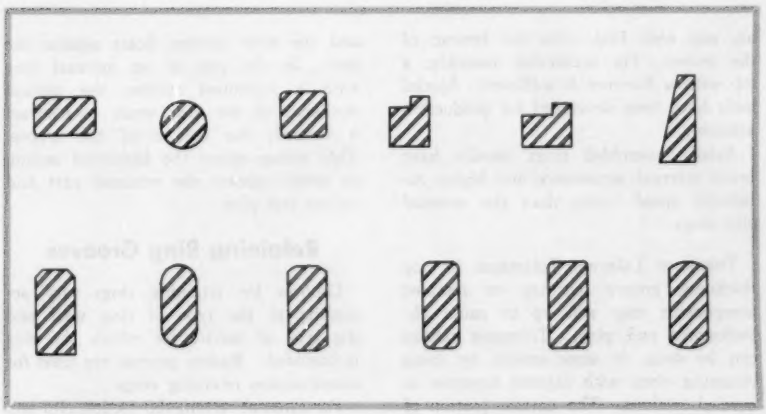


Fig. 1—Typical section shapes for wire-formed rings.

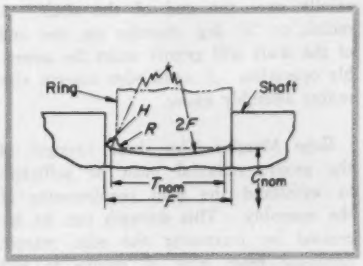


Fig. 2—In external-ring applications where bending or fatigue loads are critical, specify this alternate groove design. Important dimensions are: Groove radius H, ring radius R, groove diameter C_{nom}, groove width F, and section thickness, T_{nom}.

Any increase in width or thickness, however, increases the effort required to assemble the ring into the groove.

Although rings can be made with almost any combination of section width and thickness, rectangular-section thicknesses are usually 2 to 5 per cent of the diameter of the shaft or bore. The width of these sections varies from two to three times the thickness.

In most cases, the retaining ring will withstand greater shear loads than the groove material because of the strength of the hardened spring steel section.

Overexpansion or contraction during assembly can affect the ring's ability to seat and hold itself tightly against the bottom of the groove, thereby affecting its performance. Assembly time can be minimized by selecting the smallest ring section which will still meet requirements. Heavy section rings with relatively small diameters are the most difficult to assemble.

Configuration of Retained Part: Under ideal conditions the shaft and the retained part should have strength equal to or better than the ring. The groove should be square, concentric, and held to such dimensions that a close slip fit is provided with the sides of the ring. The bearing surface of the retained part should be perpendicular to the axis of the shaft with no corner radius.

These optimum conditions would allow maximum thrust to be applied before the ring deflected and eventually pushed out of the groove. If these conditions cannot be met in practice, be sure that wire-section corner radius and mating-part radius and tolerances provide an adequate flat surface for the ring to bear against.

Clearance: Allow sufficient design clearance to assemble the rings with a minimum of effort. Radially assembled, or clip, retaining rings require accessibility to the side of the shaft. Rings used internally in bores require adequate space for tool insertion.

External closed rings are assembled axially over the end of the shaft. A radius or 30 deg chamfer on the end of the shaft will greatly assist the assembly operation. A small edge margin also makes assembly easier.

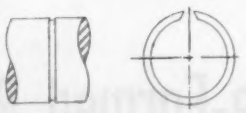
Edge Margin: The shear strength of the groove material must be sufficient to withstand the load requirements of the assembly. This strength can be increased by increasing the edge margin (distance from edge of groove to end of shaft) or by increasing the strength of the groove material.

Axial or Radial Rings. External clip rings are easier to install than axially assembled rings, and require fewer tools. These rings are designed to be driven on, gap ends first, over the bottom of the groove. For occasional assembly, a tap with a hammer is sufficient. Special tools have been developed for production assembly.

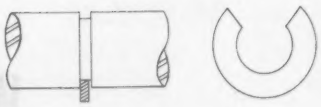
Axially assembled rings usually have better external appearance and higher rotational speed limits than the external clip rings.

Tolerance Take-up: Tolerances in ring thickness, groove location, or retained components may add up to cause objectionable end play. Tolerance takeup can be done, to some extent, by using retaining rings with tapered keystone or beveled sections. The narrow portion of the section thickness is in the groove, and the wide portion bears against the part. In the case of an external ring with a keystoned section, the natural resiliency of the ring tends to contract it towards the bottom of the groove. This action causes the keystoned section to wedge against the retained part and reduce end play.

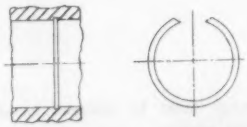
Table 1—Wire-formed Retaining Rings



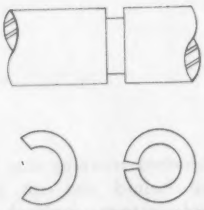
General-Purpose Rectangular-Section External Ring
Standard size range: ⅛ to 5 in. Assemble axially to hold parts on shafts. Special materials, finishes, or sections can be obtained. Several series of these rings are made to retain snap-ring-type bearings, SAE standard bearings and standard needle bearings.



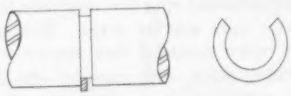
Extra-Wide Rectangular-Section External Clip Ring
Standard size range: ¼ to 13/16 in. Used where wider bearing surface is desired.



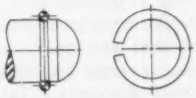
General-Purpose Rectangular-Section Internal Ring
Standard size range: ⅜ in. to 5 in. diam. for general application, up to 8 in. for standard SAE bearings. Assemble axially in bores and housings to retain parts. Several series of these rings are made to retain snap-ring-type bearings, SAE standard bearings, and standard needle bearings.



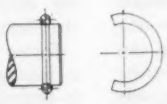
Annealed Rectangular Section External Clip Ring
Standard size range: 3/16 to ⅝ in. Ring slips over groove, then is mashed into place. Used where load is light and soft part of assembly bears against ring.



Rectangular-Section External Clip Ring
Standard size range: ⅛ to 1½ in. diam. Assemble perpendicular to axis of shaft, snap into groove. Square section general purpose clip rings are made in sizes ⅛ to 2½ in. diam.



General-Purpose Round-Section External Ring
Standard size range: ⅛ to 2¼ in. Used in same general applications as rectangular rings but where less load-bearing ability is needed.



Round-Section External Clip Ring
Standard size range: ⅛ to 2¼ in. Slip over shafts to retain parts. Less load-bearing ability than closed round-section ring.

Retaining Ring Grooves

Grooves for retaining rings vary according to the type of ring used and the type of service for which the ring is intended. Radius grooves are used for round-section retaining rings.

For external rectangular-section clip and closed rings, groove width should be 1.15

Table 2—Wire-formed Retaining Ring Thrust Load Capacities

Nominal Diam. (in.)	Section Thickness (in.)	Section Width (in.)	Thrust Capacity (lb)
	External Rings		
1	.047	.094	1,530
2	.062	.125	3,520
3	.094	.188	9,180
4	.109	.219	13,100
5	.156	.312	24,480
	Internal Rings		
1	.042	.078	1,450
2	.062	.125	3,520
3	.094	.188	9,180
4	.109	.219	13,100
5	.141	.281	21,042

times the ring-section thickness. This groove width is the absolute minimum which will accept standard rings. It may be desirable to specify larger minimums and tolerances to be consistent with design requirements. The important consideration is to locate the groove, within the accuracy required by the design, from the side of the groove on which the ring will bear when assembled. The maximum groove radius should be equal to the minimum ring corner radius, or smaller.

For external rings, groove diameter C_{nom} is

$$C_{nom} = B_{nom} - 0.6\,W_{nom}$$

where B_{nom} = nominal diameter of shaft, in., and W_{nom} = nominal ring-section width, in. Use a tolerance of 0.003 in. for shaft sizes ⅞ through 15/16 in. and 0.005 in. for sizes 1 in. and larger.

For internal retaining rings, groove diameter, C_{nom} is

$$C_{nom} = B_{nom} + 0.6\,W_{nom}$$

In both of these cases, 30 per cent of the wire-section width is in the groove at a given point on the ring's periphery.

In applications where shafts are subjected to critical bending loads or fatigue, alter the groove by putting a radius on the bottom, Fig. 2, to minimize stress concentrations.

Thrust Capacity: The type of loading has a direct influence on the load capacity of the ring. Shock, vibration, or dynamic loading will reduce ring thrust capacity to as much as 60 per cent of the static load. Under dynamic loading there should be sufficient clearance in the groove to allow the ring to reseat itself in the bottom of the groove between intervals of loading. Otherwise, the effect of cyclic load can accumulate, eventually working the ring out of the groove.

Usually static ring failures occur when the ring groove is distorted sufficiently to allow a section of the ring to tend to turn inside out, or deflect axially.

Wire-section thickness and width, as well as groove depth, all affect the ring's resistance to axial distortion under load. When shafts or housings are made of soft steel or nonferrous materials, the groove dimensions will be distorted under excessive load, allowing the ring to deform for lack of support. Therefore, thicker ring sections are necessary in grooves formed in these relatively soft materials.

Since rings usually fail by buckling, rather than shearing, the thrust load capacity of wire-formed rings can be determined by testing them in mild-steel shaft assemblies. If the load where the ring begins to deflect is taken as the limit value, safe capacity in normal applications is usually considered to be 60 per cent of the limit. In some cases where only static loads are present, 90 per cent of the capacity may be used for design calculations. Typical thrust-load capacities are listed in Table 2.

DESIGN DATA

CHAPTER 18

Blind Rivets

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BLIND riveting is a technique for setting a rivet without access to the reverse side of the joint. In this process, the rivets are inserted and clinched from the same side.

For many years, joints which required blind riveting simply were not designed, and blind rivets were regarded as interesting, though somewhat impractical, fastening devices. Now, rivet design has progressed to the state that many blind rivets are used even for accessible joints.

There are many specific reasons. Installed cost of a blind rivet is low, often less than that for methods using less-expensive fasteners. Tools are cheap, production rates are high. Blind rivets provide a neat, compact assembly. Joints can be made in any position.

Blind-Rivet Styles

There are no standards established for blind rivets. Most manufacturers make several distinctly different proprietary items to meet varying assembly requirements. As a basis for selection, three design features of these rivets merit particular attention: 1. Core style. 2. Blind-end configuration. 3. Method of setting.

Setting forces for blind rivets are applied through the rivet core. In the setting operation, the core is either removed to leave a hollow rivet or is filled to form essentially a solid rivet. The hollow core type offers advantages where weight is a factor, the filled-core type where maximum shear strength is needed.

Design of the blind ends of these rivets is quite varied. Some are open, some are completely enclosed, and others are in between these extremes. Sealing properties of the rivet vary accordingly and should be checked out under actual conditions if this requirement is critical.

The majority of the blind rivets currently in use are set with gun-type portable tools. A mandrel or pin is pulled through the rivet core by the tool to upset the blind head. With drive-pin rivets the blind head is formed by a pin, projecting from the manufactured head, which is driven into place with a hammer. A third type, the explosive blind rivet, has a chemical charge in the shank. Application of heat to the rivet head by setting iron or similar tool activates the charge to expand and set the blind head.

The recommendations presented here are based primarily on rivets set by gun-type tools. However, the same principles should apply equally to all types of blind rivets.

Rivet Materials

Blind rivets are made of various materials, including steels of different grades, aluminum, and Monel. Steel rivets are used where high strength with minimum corrosion resistance is required. They can be plated, chemically treated, or enameled.

Aluminum rivets are commonly used for exterior work or wherever corrosion resistance is needed. They are available with either a bright dip or anodized finishes.

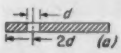
Monel rivets provide high shear and tensile strengths. They are corrosion resistant and can be used in contact with water, detergents, corrosive liquids, and atmospheres.

Design Considerations

Speed of assembly: Depending in part on joint design and operator efficiency, the speed of installing a blind rivet is also a function of placement ease and tool efficiency. In some methods the rivet must be placed in the hole; in others it is inserted in the tool, then moved to the work. Manually operated tools, such as special pliers, are ideal for widely divergent operations and can be used efficiently with no preliminary training. For speed, air-hydraulic tools are the fastest.

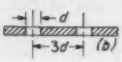
Tooling Costs: Equipment costs vary with the type of blind rivet used. Auto-

Table 1—Blind-Rivet Joint Design



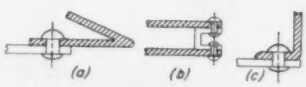
Edge Distance

Average recommended edge distance is two times the diameter of the rivet. In lightly loaded structures where the rivet performs only a holding function, this can be decreased to 1½ diameters, and in heavily loaded structures, it may be necessary to increase it to as much as 3 diameters to develop required joint strength.



Pitch

Rivet pitch should be three times the diameter of the rivet. Depending upon nature of load, it may be desirable to decrease or increase this distance. However, it is generally considered that 3 diameters overcomes the tendency of the material to fail and concentrates the load on the rivet.



Clearance

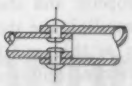
An angular section is riveted to a straight member, *a*. If the angle projects above the rivet head, it may be difficult to put the tool in to upset the rivet. One method of solving this problem is to pull the rivet from the underside of the work. In riveting the U-channel, *b*, to the outer members, the rivet must be fed from the outer side. On this joint, allow enough back-up clearance to prevent interference. At *c*, not only tool clearance, but also rivet head clearance is critical. A large diameter head may interfere with the wall.

Attaching Tubing

Attaching tubing is an application for which the blind rivet is ideally suited. At *a*, the rivet goes completely through the tubing. A very long rivet is required, but little advantage is obtained over the design shown at *b*, where a shorter length is used. The design at *c*, is recommended if the additional cost of milling or rolling the tubing with a flat on the

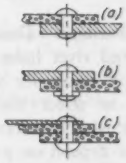
Attaching Rod

In attaching a rod to other members, usually practice is to pass the rivet completely through the rod. If this is impractical, attachment can be made through a slot milled in the rod.



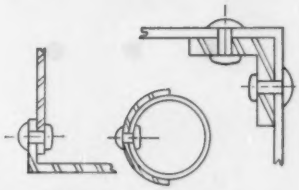
Joining Tubing

This tubing joint is a very common form of blind riveting, used for both structural and low-cost power-transmission assemblies



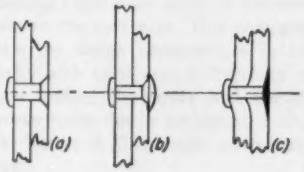
Rubber, Plastic and Fabric Joints

Some plastics, such as reinforced molded fibreglas or polystyrene, which are reasonably rigid, present no problem for most small rivets. However, when the material is very flexible or is a fabric, set the rivet as shown at *a* or *b*, with the upset head against the solid member. If this practice is not possible, use a back-up strip as shown at *c*.



Sheet Metal

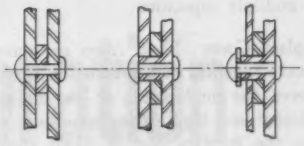
Some blind rivets are well adapted to assembly of sheet metal, others which rely on shank deformation for holding action, are not. If a choice can be made, it is always desirable to set the rivet against the thicker member. Backing it up with a washer or back-up strip in assemblies that are accessible from both sides is desirable, but not absolutely necessary.



Flush Joints

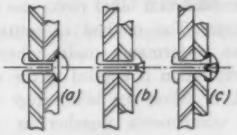
Generally, flush joints are made by countersinking one of the sections and using a taper-head rivet, *a*. Some rivets are available in either an oval or a flat top countersunk head, but not both. The rivet at *b* is capped.

Another popular method of providing flush assembly and gaining additional bearing strength is to dimple the sheet by forming a conical projection on the back of the sheets with a die, *c*. A countersink-like recess is left on the front of the sheet which allows flush mounting of the rivet head. The projections in both sheets are nested together to increase bearing strength.



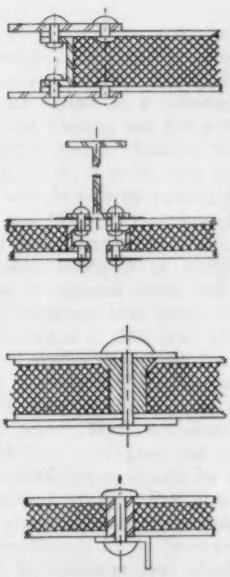
Pivoted Joints

There are a number of ways of producing a pivoted assembly, three of which are shown. Notice that the first two methods prevent the clamping force of the rivet from influencing pivot movement.



Weatherproof Joints

A hollow-core rivet can be sealed by capping it, *a*, by plugging it, *b*, or by using both a cap and a plug, *c*. To obtain a true seal, however, a gasket or mastic should be used between the sections and perhaps under the rivet head. Use of a covering seal also is sometimes recommended, although this requires forming or cutting a channel in the parts to be assembled. Where weathertight-tightness but not pressure or moisture-tightness is desirable, the sections may simply be painted.

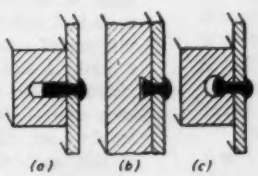


Honeycomb Sections

Inserts should be employed to strengthen the section and provide a strong joint. Otherwise, setting the rivet may deform the section and cause a structural weakness that may later result in failure.

Blind Holes or Slots

A useful application of a blind rivet is in fastening members in a blind hole. At *a*, the rivet head bears against the side of the hole only. As could be expected, this joint is not as strong as the other two *b* and *c*, but the clinching action of the rivet head provides sufficient strength for light tension loads and moderate shear loads.



matic equipment costs more than manual tools, but seldom more than a few hundred dollars. If varied joint designs are routine, it may be necessary to have tools with multiple capacities.

In-place Costs: Blind rivets are more expensive fasteners than production rivets. However, the combination of low tooling investment and high setting speed acts to reduce the in-place cost of blind rivets appreciably.

Physical Limitations: Tensional loads often do not predominate in an assembly. Frequently, compression or shear loadings are more critical and blind rivets can meet these criteria. The method of setting is the clue to performance under vibration. When compression is applied to the work in process, or when the blind rivet itself pulls the components together as it is set, vibration effects are minimized.

Material Thickness: Thin sheet can be critical in the application of some types of blind rivets, inconsequential in others. This depends on the basic rivet design and on the setting technique. If the head is formed properly and shank expansion is closely controlled, the rivet may be set in aluminum as thin as 0.020 in. Conventional practice, however, is to rivet against the thicker sheet of a combination, if it is accessible. When one component is of compressible material, a washer, placed over the rivet before setting, provides a rigid base to clinch against.

Hole dimensions: Dimensional tolerances of blind rivet holes vary with the rivet used. It is usually better and more economical to select the fastener that clinches against the surfaces of the parts and does not depend on a tight fit in the hole wall.

Joint Design Practices

Joint details pertinent to rivet spacing, edge distance, and rivet diameters are calculated much the same as for other types of rivets. Recommended practices are summarized in Table 1.

Elimination of the requirement for accessibility to the back of the work allows a certain flexibility of design, but there are some restrictions, such as back-clearance requirements, that should be kept in mind.

The amount of back clearance required depends on the length of the rivet prior to being set and on the joint thickness. Some rivet types need as little as 3/16 of an inch of space.

Shape or size of the setting tool may limit a particular application. Side members of deep channel sections, as an example, may be too close to allow entry of the tool. Special accessories such as extensions can be employed in many cases; but, avoid these problems if possible.

DESIGN DATA

CHAPTER

19 Fastener Vibration

GERARD T. KLEES

Test and Development Engineer, Mechanical Laboratories, Chrysler Corp., Missile Div., Detroit, Mich.

NATURAL vibration frequency of fasteners must often be determined to alleviate or avoid problems created by resonance. Usually, fasteners are so designed that their natural frequency is well beyond the expected frequency range of vibration in actual service. This practice is not always practical, however, because of extreme frequencies or other limitations. Then, the fundamental mode of vibration of the attaching members is taken at a much lower frequency than would actually be experienced.

To find the natural frequency, the fasteners in an assembly can be considered as individual tension-compression springs. If each fastener is assumed to have the same length, diameter, and, thus, stiffness, forced vibration of the assembly mass would excite resonance of the fastener "springs" at a frequency given by

$$f_n = \frac{1}{2\pi}\left(\frac{Nkg}{W}\right)^{1/2} \qquad (1)$$

Applying Hooke's law ($k = AE/L$) and substituting in Equation 1,

$$f_n = \frac{1}{2\pi}\left(\frac{AENg}{LW}\right)^{1/2}$$

or, for circular fasteners,

$$f_n = \frac{D}{4\pi}\left(\frac{EgN\pi}{LW}\right)^{1/2}$$

For steel ($E = 30 \times 10^6$ psi), this equation reduces to

$$f_n = 15{,}200\,D\left(\frac{N}{LW}\right)^{1/2} \qquad (2)$$

and for aluminum ($E = 10 \times 10^6$ psi),

$$f_n = 8770\,D\left(\frac{N}{LW}\right)^{1/2} \qquad (3)$$

Equations 1 and 2 are solved in the nomograph on the next page. This nomograph relates the design parameters of a solid cylinder with axial natural frequency and weight loading. Frequency and nominal-diameter scales can be multiplied or divided by factors of 10 to obtain different scale ranges.

Example 1: An electric motor which runs at 30,000 rpm is to be tied down by four mounting bolts. Bolt resonance is not to occur during operation. Design limitations dictate a minimum base thickness (bolt length) of 1 in., and a bolt material of steel. The motor weighs 100 lb. Determine required nominal diameter of mounting bolts.

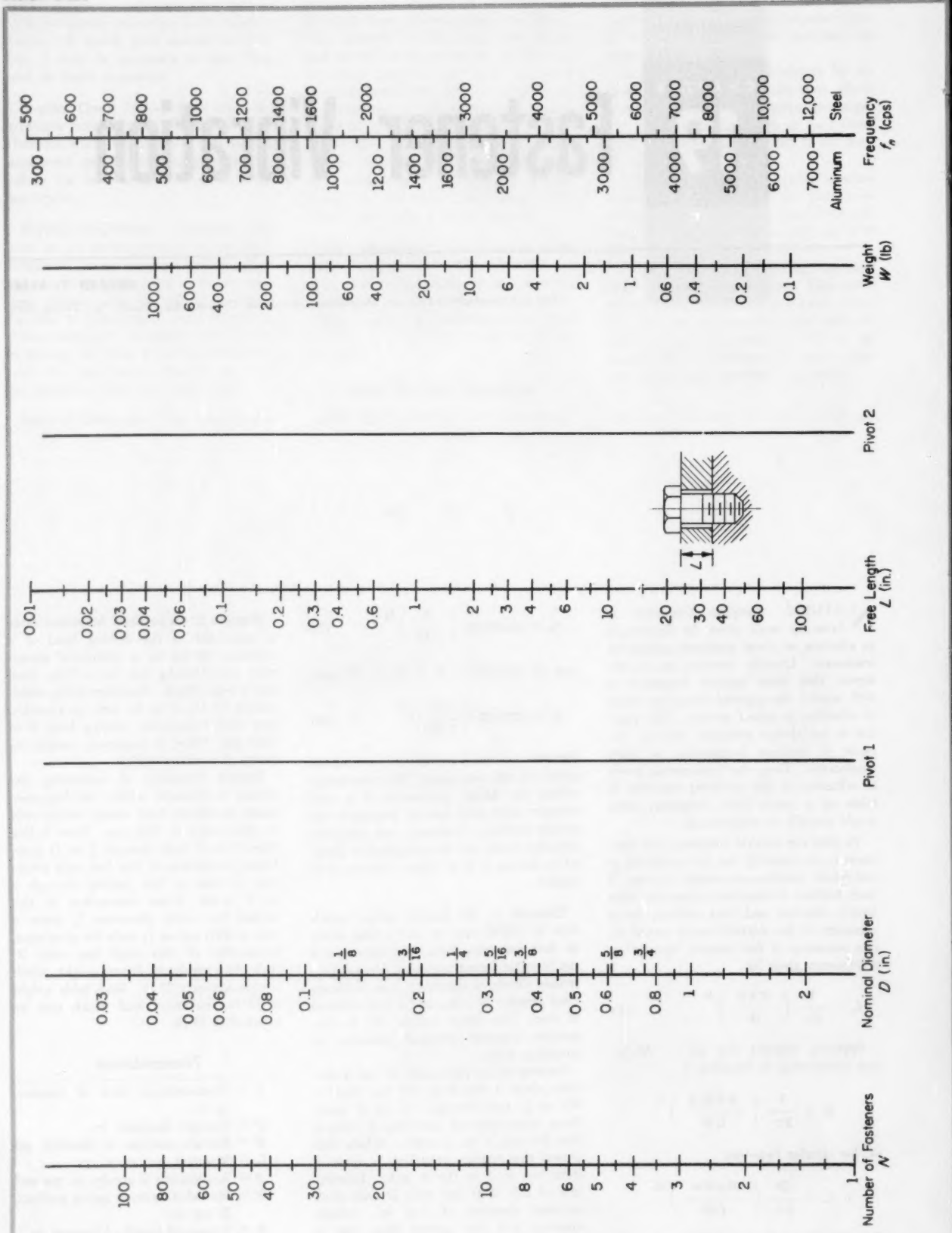
Starting at far right scale of the nomogram, draw a line from 500 cps (30,000/60) on f_n scale through 100 on W scale. From intersection on pivot-line 2, draw a line through 1 on L scale. Where this second line crosses pivot-line 1, draw a third line to 4 on the N scale. Intersection of this third line with D scale gives required diameter of 0.16 in. Closest nominal bolt size greater than this is 3/16 in., which is the desired bolt diameter.

Example 2: An auxiliary horizontal table is connected to the driving head of a vibration exciter by a cylindrical aluminum rod. Driving rod has a 2-in. diam and a 3-in. length. Auxiliary table, which weighs 10 lb, is to be used in vibration tests with frequencies ranging from 0 to 2000 cps. What is maximum weight capacity of auxiliary table?

Because resonance of connecting rod cannot be tolerated within test frequency range, maximum total driven weight will be determined at 2000 cps. Draw a line from 1 on N scale through 2 on D scale. From intersection of this line with pivot-line 1, draw a line passing through 3 on L scale. From intersection of this second line with pivot-line 2, draw a line to 2000 cps on f_n scale for aluminum. Intersection of this third line with W scale gives maximum driven weight, which is approximately 25 lb. Since table weight is 10 lb, maximum load which may be attached is 15 lb.

Nomenclature

- A = Cross-sectional area of fastener, sq in.
- D = Fastener diameter, in.
- E = Young's modulus of elasticity, psi
- f_n = Resonant frequency, cps
- g = Acceleration of gravity, in. per sec^2
- k = Individual fastener spring gradient, lb per in.
- L = Unsecured length of fastener, in.
- N = Number of fasteners
- W = Secured static weight, lb


Frequency f_n (cps)
Steel
Aluminum
Weight W (lb)
Pivot 2
Free Length L (in.)
Pivot 1
Nominal Diameter D (in.)
Number of Fasteners N

DESIGN DATA

CHAPTER 20

Fastener Evaluation

HARRY S. BRENNER

President, Almay Research & Testing Corp., Los Angeles, Calif.

WHEN a new design is evaluated, testing of fasteners is an economical practice. It tends to avoid future troubles. Strength is only one of the factors to be considered in fastener selection and application. Test programs in the design phase should encompass as much of the expected performance range as possible. Logically, performance is determined prior to production.

It is sometimes difficult to duplicate complex conditions in a laboratory, but with an understanding of the problems and objectives involved, enough useful data can usually be developed to substantiate a "good design."

Unfortunately, failures do occur in service. To avoid failure, the identification of the mode or type of failure is as much a part of the job as the preliminary design phase. A bolt fractures — and the determination of whether or not it is a brittle or ductile failure, possible fatigue failure, or maybe an isolated case resulting from some metallurgical defect can establish the proper corrective action to be taken.

Fig. 1—Idealized examples of threaded fastener failures due to tension loading.

Types of Failures

Fatigue Failures: The phenomenon of fatigue failure is discussed in Chapter 5, and methods of preventing fatigue failure in riveted and bolted joints are covered in Chapter 6.

A fatigue failure is usually fairly easy to recognize by inspection. Look for two distinct zones on the surface of failure. One zone, close to the periphery of the failure, will have a smooth, fine-grained, velvety appearance. This zone, which is the original progression of the fatigue crack, has been smoothed by rubbing of the surfaces. On ferrous parts, this zone will usually have a pattern of clam-shell shaped rings which emanate from the point of highest stress concentration.

The second zone of a fatigue failure area resembles an ordinary static tensile fracture. This is where final failure occurred. Sometimes, especially in fine-grained or case-hardened materials, these two zones are difficult to distinguish.

Static Failures: A static or stress rupture fracture is an instantaneous failure caused by application of loads beyond the static capacity of the fastener.

Although there is no definite dividing line, these fractures are referred to as ductile or britttle failures, depending on the nature of the failed material.

When a ductile fastener fails under a tension load, there are definite signs of elongation, or necking down, before final failure. Usually with steel fasteners the faces of the failed part will have a cup-and-cone appearance. The texture of the failed surface will be silky in appearance.

Wrought iron will fail under tension loading with a ragged, fibrous fracture. Cold-worked material or material with an internal stress condition will fail with the appearance of streaks or ridges radiating outward from a point near the center, Fig. 1. This is known as a star fracture.

Metals fail in compression by shearing on a 45-degree plane.

A ductile metal in torsion will show evidence of deforming before failure, then it breaks in a plane perpendicular to the axis, Fig. 2.

A brittle material in tension will break straight across, leaving a very rough, granular surface, Fig. 1. In a torsion failure, a brittle material shows no signs of deformation, but breaks in a helicoidal pattern, Fig. 2.

Thread Stripping: Stripping of screw threads can be a vexing problem. If it occurs, check the parts for excessive decarburization, Fig. 3. Or, re-evaluate the relationship between applied torque and induced tension. Properly specified installation-torque values will provide the correct preload without the danger of thread stripping.

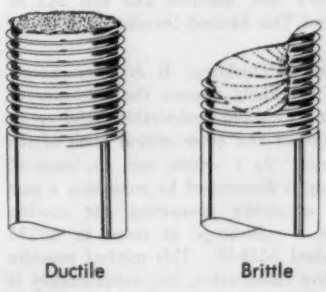


Fig. 2—Idealized examples of threaded fastener failure due to torsion loading.

Environment: Some equipment is required to operate at a range of temperatures from — 300 F to over 2000 F. At the cryogenic temperatures, sharp increases in tensile strength may be realized, with corresponding brittleness. High-temperature applications introduce problems such as relaxation, galling, and lower strength properties. The specialty corrosion-resistant steels have been successfully used at high temperatures in various fastener configurations, but are notorious galling agents when used in combination as bolts and nuts. Application of silver plate as a thread lubricant on nuts has helped to alleviate many of the galling problems in the medium-temperature range.

Dimensional Examination: Fastener interchangeability is of the essence. In addition to obvious checks for prime dimensions (diameter, length, head configuration, slot or recess, etc.) special tests may be required to check straightness of shank, squareness of headed fasteners, squareness of nut face, concentricity of threads, etc. Where standard tools are not adaptable for measurement of special properties, such as angle of countersunk-head fasteners, thread-root radius, and fillet radius under bolt heads, reliance is placed on measurement by means of optical or shadowgraph comparator. MIL-STD-105 is widely followed for sampling inspection.

Thread Check: For measurement of external threads, a variety of techniques are used, including three-wire measurement check, snap gage, go no-go ring gage, Tri-roll gage, and PD micrometer. For inspection testing of internal threads, go no-go plug gages are most frequently employed.

Hardness: The hardness test has found value as an approximation of the tensile strength of ferrous-alloy fasteners. The hardness reading is taken at or near the center of the head or at the end of the fastener. For low-strength alloys, the Brinell hardness test is most often used; for the higher strength alloys, the Rockwell "C" scale hardness test is generally applicable. Standard procedures for conducting hardness tests are described in standards such as ASTM E10-58T and E18-57T and Methods 242 and 243 of Federal Test Method Standard No. 151.

Plating Thickness: It is often necessary to closely control the thickness of plating to avoid undesirable build-up in the thread and other critical areas of the fastener. As a referee test, thickness of plating is determined by sectioning a part and accurately measuring the coating under a microscope as noted in ASTM Standard A219-58. This method provides positive information, but unfortunately is a destructive test.

Several nondestructive measuring devices have been developed for quick determination of coating thickness. The principle of operation is based on the loss of magnetic attraction of a measuring magnet when such nonmagnetic coatings as cadmium or zinc are applied on a ferrous or magnetic base alloy, or the increase in magnetic attraction when a magnetic plating (such as nickel))is employed on a nonmagnetic base alloy. Method No. 522 of Federal Test Method Standard No. 151 and Appendix I to ASTM A219-58 cover this testing method.

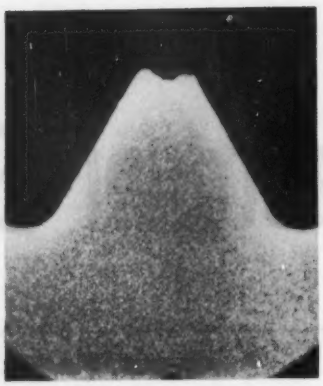


Fig. 3—Metallurgical examination of screw thread. White area represents decarburized portion of thread. Failure of a decarburized, or case hardened fastener is sometimes difficult to distinguish from a fatigue failure, because of the two-zone appearance.

Discontinuities: Discontinuities may appear internally or on the surface and include seams, cracks, splits, inclusions, laps, and other related defects. The presence of discontinuities will have a detrimental effect on fastener performance, especially when it is subjected to dynamic or fatigue loads.

Many surface discontinuities cannot be detected by visual observation, so there is a need for more discerning methods of inspection. Magnetic particle inspection is used on ferrous or magnetic-base materials. For nonmagnetic materials, the parts are immersed in a liquid fluorescent penetrant and the presence of a discontinuity is observed under ultra-violet light. Military specifications for magnetic particle inspection (MIL-I-6868) and fluorescent penetrant inspection (MIL-I-6866) detail these methods.

Internal defects require more sensitive detection techniques. X-rays (radiography) and ultrasonic testing have been used.

Destructive Testing

Tensile Strength: For the majority of the common standard fasteners, tensile strength is perhaps the most important single physical property. In the determination of this property in a tensile testing machine, exercise care to assure proper alignment and loading of the test parts. Threaded fasteners (bolts, studs, screws, etc.) should be tested using a nut or threaded fixture with sufficient thread engagement and of sufficient hardness to develop the full strength of the fastener. Test the actual fastener full scale, if the capacity of the available testing machine permits. For bolts with

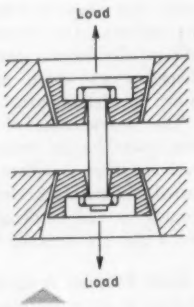


Fig. 4—Tensile test fixture. Load should be applied parallel to the bearing faces of bolt and nut.

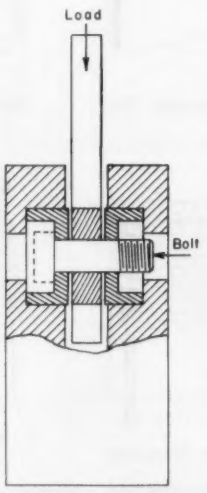


Fig. 5—Shear test fixture. Fasteners are usually tested in double shear to insure even load distribution and pure shear stresses.

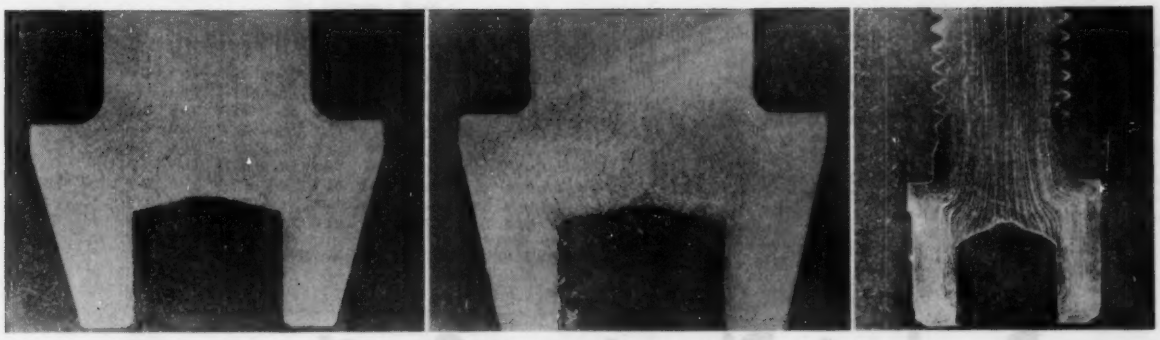


Fig. 6—Macro-photos showing grain flow indicative of good heading technique.

diameters over 1 in., standards have been developed which relate bolt strength to the strength of a reduced diameter section in the bolt. Procedures and techniques for the testing of steel fasteners have been covered in detail in ASTM Specification A370-54T.

Where yield strength is a requirement, determination can be made during the course of the tensile test by several methods. The "drop of the beam" method is generally acceptable for low-alloy steels. Yield strength of higher strength fasteners often requires using an extensometer or dividers.

Shear Strength: Shear strength of a fastener is often related on a percentage basis to the tensile strength. For example, shear strength of many steel fasteners is set at from 56 to 60 per cent of the ultimate tensile strength. Tests are usually conducted in double shear to rigidly support the test specimen. The test fixture should be sufficiently harder than the test specimen to prevent distortion or undue bending.

Fatigue Strength: Detailed methods for evaluating high performance fasteners in fatigue have been outlined in National Aircraft Standards Committee Specification NAS1069.

Stress Rupture and Relaxation: Stress-rupture strength is a direct function of temperature, load, and time. Two identical parts subjected to the same static load but held at different elevated temperatures, will result in two distinct life ratings.

Stress-rupture criteria are further complicated for threaded fasteners due to the notch sensitivity of certain materials. Relaxation, most commonly applied to bolts and nuts, is a condition where continued exposure to temperature and load results in a lessening of the original clamping strength due to creep in the fastener and joint. Most product specifications are primarily concerned with the rupture strength of the fastener itself, and require a test of the fastener, or of a test specimen fabricated from the fastener material. Such types of tests are carried out in standard creep, and stress-rupture testing machines and equipment.

Vibration: Although much is to be desired in the vibration test methods for individual product evaluation, MIL-N-25027 and MIL-F-18240 outline test techniques which have been used to some extent.

Bend: As a measure of the ductility and/or toughness of finished bolts, a bend test is occasionally used. The test, which is specified for the shank portion (rather than the threads), requires the bolt to be forcibly bent over a rod or mandrel having the same diameter as the part under evaluation. Premature fracture or rupture of the test specimen constitutes a failure.

Metallurgical Examination: One of the most valuable tests is the metallurgical examination of fasteners. This can reveal the history of the fastener and the presence of flaws. Metallurgical examination usually includes a study of the macro-structure to determine grain-flow patterns and proper heading and rolling technique. Micro-examination determines plating thickness, presence of decarburization, presence of laps, seams, or other discontinuities. High powered micro-examination is also used to study grain structure which is indicative of heat-treating technique.

Torque: Industry specifications establishing torque control limits have been released by the Industrial Fasteners Institute, and by the Military Services under MIL-N-25027.

Driveability: The driveability test is used for tapping screws. This test determines whether or not screws can form their own threads when properly installed. It is performed by driving screws in a test plate until the tapered threaded point of the screw is completely through the plate. The threads of the screw should not be deformed during the process of forming or cutting a mating thread in the test plate.

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Product Directory Section

FASTENERS presented in this Product Directory are classified as shown in the Contents. Nails, screws, and other fasteners for wood materials, as well as fasteners suited solely for buildings, bridges and other heavy construction, are not included. Similarly, clamping devices, and joining processes such as welding, stitching, etc. are beyond the scope of this book.

Each basic fastener type in the classification is covered by a separate item and illustration. Items within each category are listed alphabetically by title for easy reference.

Only materials that are supplied as standard are listed. However, a number of standard finishes are also usually made available, as well as special material and finish options.

Sizes, too, are only the nominal fastener sizes, length and body styles that are supplied as standard. Here again, a range of standard modifications and specials to meet different requirements is offered by most manufacturers.

The listed sources are either the pertinent industrial standard covering the specific fastener type or the manufacturer with primary or exclusive proprietary or manufacturing rights. In many instances, however, companies other than those listed are also licensed to produce the same fastener.

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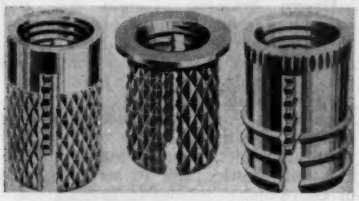
PRODUCT DIRECTORY

CHAPTER

21 Inserts

THE insert is basically a special form of nut designed to serve the function of a tapped hole in blind or open locations. It may be used to provide high strength threads in soft materials where frequent assembly and removal of threaded fasteners are required, to provide a threaded hole with locking features, or to provide a thread anchor in materials where tapping is impractical. Comparable application characteristics are also offered in design by the various anchor, clinch, and weld nuts.



Banc-Lok Insert

Form: Slotted, internally threaded self-locking insert with exterior annular fins or knurled surface. Insert is pressed into blind or open hole, causing slotted sections at blind end to bend inward. Entrance of threaded fastener expands slotted sections, driving fins or knurls into wall of hole to hold insert in place. Radial inward pressure of insert threads provides locking action.

Design Features: Reusable. Provides strong self-locking threads in blind holes in thin sections and soft materials. Locking action of insert is controlled by varying size of mounting hole. Does not mar part surface. Eliminates need for molded-in inserts. Can be adapted to high production machine assembly methods.

Materials: Aluminum, ½ hard brass, stainless steel and mild steel.

Sizes: No. 2-56 to ⅜-16 internal threads. Lengths from 5/32 to ⅝-in. Insert styles include headless body with knurled surface or one, two or three fins; headed body with knurled surface and conventional or reverse threads.

Source: Boots Corp., Norwalk, Conn.

Banc-Lok Tapped Holes

Form: Slotted, internally threaded self-locking insert with double-tapered sides.

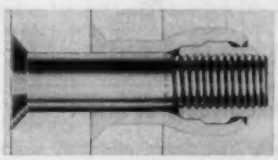
Insert is pressed into through hole in thin section, causing slotted blind ends to move inward. Entrance of threaded fastener expands slotted sections to wedge insert in place. Radial inward pressure produces locking torque on screw threads.

Design Features: Reusable. Can be installed with standard tools. Size of mounting hole determines locking torque of threads. Insert can accommodate thickness variation range of 0.015-in. Provides strong threaded hole in sheet materials too thin to tap.

Materials: Aluminum, ½ hard brass, stainless steel, and mild steel.

Sizes: No. 2-56 to ¼-20 internal threads. Grip lengths for material thickness from 0 to 0.160 in Standard heads are flat and countersunk.

Source: Boots Corp., Norwalk Conn.



Blind Nut

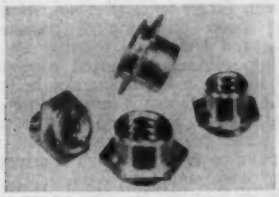
Form: Two-piece, nut-plate type assembly consisting of countersunk headed sleeve and threaded expander nut. Sleeve and expander nut are inserted in prepared hole. Expander nut is pulled up by installation tool mandrel into sleeve end. Expansion of sleeve end securely locks the two pieces together.

Design Features: Provides a high-strength blind fastener for machine and aircraft structures and related applications. Resists vibration. Can be used in collapsible panel materials since grip length is controlled. Provides flush mounting. Can be assembled with either hand tools or powered equipment.

Material: Stainless steel.

Sizes: No. 4-40 to ⅜-24, UNF threads, Class 3. Head style of sleeve is 100 deg standard countersunk or AN426 countersunk.

Source: Hi-Shear Rivet Tool Co., Torrance, Calif.



Captive Nut

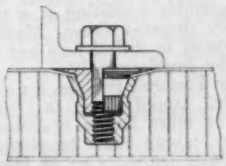
Form: One-piece, internally threaded, all-metal insert. Insert body has annular grooves separating hex-shaped section from round section of reduced diameter. Insert is pressed into prepared hole, round section first, and hex-shaped section is imbedded in part surface. Cold flow of material into grooved section of shank and around hex-shaped section, locks insert in place.

Design Features: Provides a strong, flush-mounted tapped hole in aluminum or brass sheet-metal parts. Can be assembled from one side in blind locations. Can be installed on standard presses.

Material: Stainless steel.

Sizes: No. 4, No. 6, and No. 8 NC-2B, and No. 10 NF-2B internal threads. Material thicknesses from 1/16 to ¼ in. Body styles include round and hex shanks of varying lengths, locking and nonlocking types.

Source: National Radio Co. Inc., Melrose, Mass.



Delron Blind Insert

Form: Single-unit, all-metal, sandwich-panel insert consisting of preassembled internally threaded sleeve and headed plug held together by interlocking splines. Sleeve is inserted in drilled hole in panel cover sheet and clinched to cover sheet with pull-type tool. Clinching operation expands sleeve and dimples cover sheet which is gripped between sleeve and head of plug.

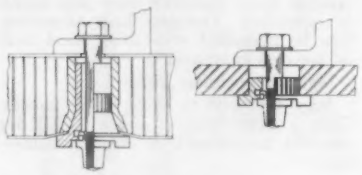
Design Features: Provides a strong, permanent, threaded blind hole in sandwich panels. Provides a flush mounting surface. Interference fit and splines assure tight assembly of parts. Adaptable to manual or powered assembly tools.

Materials: Carbon and stainless steel.

Sizes: No. 6-32 to ⅜-24 internal threads.

Source: The Delron Co. Inc., South Gate, Calif.

(See Ad, Page 112)



Delron Floating Nut

Form: Single-unit, all-metal, sandwich-panel insert consisting of preassembled sleeve and body held together by interlocking splines. A flanged cone nut is held loosely in a circular slot in the top of the body. Sleeve is inserted in counterbored hole in panel and body is pressed into seated position, expanding sleeve and dimpling cover sheet which is gripped between sleeve and body head.

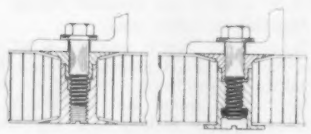
Design Features: Provides strong, permanent, load-carrying threads in sandwich panels. Floating nut allows for misalignment of attached parts. Insert acts as a supporting column between the cover sheets to strengthen panel section at load-bearing points. Interference fit and splines assure tight assembly of parts.

Materials: Body and sleeve are aluminum or steel. Nut is steel.

Sizes: No. 6-32 to 5/16-24 nut threads. Insert styles include structural, and structural-flared types.

Source: The Delron Co. Inc., South Gate, Calif.

(See Ad, Page 112)



Delron Grommet Fastener

Form: Two-piece, internally threaded insert assembly consisting of a plug and internally threaded sleeve. Mating parts are mounted in drilled hole and held together by interference fit.

Design Features: Provides a strong, self-retaining, tapped hole in lightweight panels or other fragile structures where fastening takeup must be limited to a specific grip length. Can be installed by hand or machine. Can be conveniently and permanently installed at subassembly. Interference fit assures tight assembly of parts and a positive aligned grip.

Material: Aluminum, carbon steel, and stainless steel.

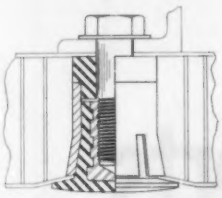
Sizes: No. 4 to 5/16-in. internal threads. Body styles include locking and nonlocking types. Head styles include flush and nonflush.

Source: The Delron Co. Inc., South Gate, Calif.

(See Ad, Page 112)

Delron Insulating Insert

Form: Single-unit, metal-and-plastic, sandwich-panel insert consisting of aluminum sleeve with plastic plug, and a plastic body with a threaded steel liner. Sleeve is inserted in counterbored hole in panel and body is pressed into seated position, expanding sleeve and dimpling cover sheet which is gripped between sleeve and body head.



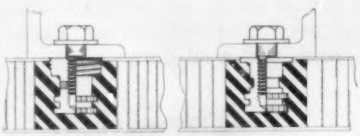
Design Features: Provides a strong, permanent, insulated, threaded hole in sandwich panels. Develops high shear and tensile pull-out strength. Used in thicker panels where heat and dielectrical conductivity are critical problems. Steel threads are completely isolated from outside cover sheet of panel.

Materials: Plastic and steel.

Sizes: No. 10-32, 1/4-28, and 5/16-24 internal threads. Minimum panel thickness is 1½ in.

Source: The Delron Co. Inc., South Gate, Calif.

(See Ad, Page 112)



Delron Molded-In Insert

Form: One-piece, all-metal, sandwich-panel insert. Insert is slipped through hole in cover sheet of panel, or threaded into hole, then cavity in panel is filled with potting material to bond insert in place.

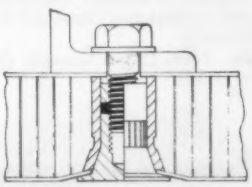
Design Features: Provides strong, permanent, threaded hole in sandwich panels. Thread-in type is supported by cover sheet for alignment and curing of potting material.

Materials: Aluminum, corrosion-resistant steel, and carbon steel.

Sizes: No. 4-40 to 3/8-24 internal threads. Various lengths for panel thicknesses from 5/16 in. up. Body styles include locking and nonlocking threads.

Source: The Delron Co. Inc., South Gate, Calif.

(See Ad, Page 112)



Delron Structural Insert

Form: Single-unit, all-metal, sandwich-panel insert consisting of preassembled sleeve and internally threaded body held together by interlocking splines. Sleeve is inserted in counterbored hole in panel and body is pressed into seated position, expanding sleeve and dimpling cover sheet which is gripped between sleeve and body head.

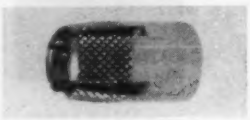
Design Features: Provides a strong, permanent, threaded hole in sandwich panels. Acts as a supporting column between the cover sheets to strengthen panel section at load bearing points. Provides a flush mounting surface. Interference fit and splines assure tight assembly of parts.

Materials: Aluminum, stainless, and carbon steel.

Sizes: No. 4 to 3/8 in. internal threads. Grip lengths for panel thicknesses from 1/4 in. up. Body styles include closed and open end designs, locking and nonlocking threads, and a flared type for thin panel installation.

Source: The Delron Co. Inc., South Gate, Calif.

(See Ad, Page 112)



Dodge Expansion Insert

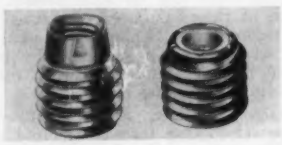
Form: Two-piece preassembled insert consisting of four-eared spreader member mounted in slotted internally threaded metal shield. External surface of slotted shield sections is knurled. Insert is mounted in drilled or molded hole and spreader member is driven downward, expanding slotted end to drive knurls into hole wall.

Design Features: Torque and pull strength of insert is comparable to molded-in insert. Can be placed by hand or machine-fed into hole. Internal threads are not contacted during expansion operation; inside sufaces of slots carry forces. Shoulder in shield locks spreader in fully expanded position. Can be used for air-tight assemblies. Used primarily in die-cast and plastic parts to serve function of conventional molded-in insert.

Materials: Brass.

Sizes: No. 4-40 to No. 10-32 internal threads. Thread lengths from 3/16 to 3/8 in.

Source: Phelps Mfg. Div., Heli-Coil Corp., Danbury, Conn.



Esna Locking Insert

Form: Externally and internally threaded bushing. External threads are modified American National thread form which provides self-locking interference fit in tapped hole. Internal threads have either nylon locking collar (under 250 F) or all-metal locking device (over 250 F) for locking screw fasteners.

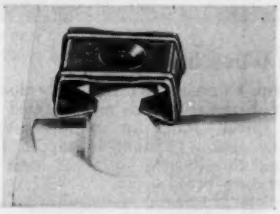
Design Features: Provides strong, wear-resistant tapped hole. Can be installed in any material with hardness less than Rockwell C-25 by tapping hole with standard Class 2 controlled-root tap. Internal threads accept AN bolt thread lengths. Insert develops full load strength of AN bolts in aluminum, magnesium, and mild steel, and increases load capacity of plastic materials. In assembly, action of external thread on socket threads pro-

vides equivalent of selective fit, sealing external threads against leakage and producing positive locking action that resists loosening effects of vibration and backing-out torque of bolt. Insert can be removed and reinserted.

Materials: Ste l.

Sizes: No. 10-32 to ⅜-24 internal threads, Class 3B.

Source: Elastic Stop Nut Corp. of America, Union, N. J.



Garrett Clip-On Fastener

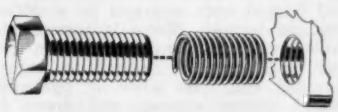
Form: One-piece, all-metal, thread anchor made as box-shaped stamping. Fastener is pressed onto hollow plastic boss and is held in position by four gripping edges which clamp against boss surface under spring action. Thread impression in face of stamping is designed to receive standard screw threads.

Design Features: Provides low-cost thread anchor for blind or open locations in hollow sections where tapping is impractical or undesirable. Does not require special tools for assembly. Permits greater tolerances in the molding of plastic bosses which are to be used as screw anchor points.

Materials: Spring steel.

Sizes: Standard screw thread sizes.

Source: George K. Garrett Co., Philadelphia, Pa.



Heli-Coil Insert

Form: Precision-formed coil of diamond-shaped wire. When seated in tapped hole, coil provides standard-size 60 degree threads.

Design Features: Provides high-strength, permanent threads in soft materials or thin sections. Driving tang, which can be broken off, is located at bottom turn of coil to facilitate installation. Insert diameter is slightly oversize; when wound into properly tapped hole, coil locks in place and will withstand severe vibration loads without loosening.

Materials: 18-8 stainless steel wire with an ultimate tensile strength of about 200,000 psi.

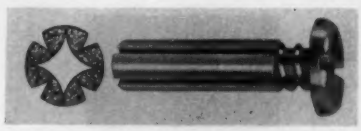
Sizes: No. 4 to 1½ in.; NC UNC, NF, and UNF internal threads; Classes 2, 2B, 3, 3B. Lengths from 1 to 3 diameters.

Source: Heli-Coil Corp., Danbury, Conn.

(See Ad, Page 107)

Hi-Red Plastic Screw Anchor

Form: One-piece, screw anchor consisting of headless grooved, plastic sleeve with diamond shaped hole. Sleeve is driven into predrilled hole, then screw with tapered thread is driven into sleeve. Sleeve



expands against hole wall as screw is driven to lock in place.

Design Features: Provides strong, low-cost, easily installed screw anchor for blind locations in thick sections. Can be cut to any required length with pliers, knife, or saw. Does not require special assembly tools. Operating temperature range is from −78 to 220 F. Each sleeve size will accept different screw sizes.

Material: Ethyl cellulose.

Sizes: No. 4 size up, sheet-metal screw threads. Lengths from ¾ to 3 in.

Source: Holub Industries Inc., Sycamore, Ill.

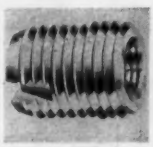
Hi-Shear Insert

Form: Two-piece insert assembly consisting of annular grooved sleeve and internally threaded expander nut. Sleeve and expander are inserted into prepared hole. Expander is pulled up by threaded installation tool mandrel into sleeve end. Resulting expansion during mandrel pull-up locks nut to sleeve and causes ridges of sleeve's external grooves to imbed in hole walls

Design Features: Requires only a single hole-drilling operation without counterboring and tapping. Can be installed by hand or by mechanical or automatic power tooling. High push-out, torque-out, and tensile strength values.

Materials: Sleeve is heat-treated alloy steel (160,000-180,000 psi tensile); expander is heat-treated type 431 stainless (175,000 psi shear).

Source: Hi-Shear Rivet Tool Co., Torrance, Calif.



Inserto

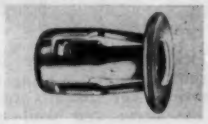
Form: Internally and externally threaded bushing. Internal threads accommodate standard screw sizes and are broached the entire length of the insert to form a hexagon socket for insertion of driving tool. External threads are self-tapping for driving into drilled or cored hole; interference fit produced by thread-cutting action and truncated thread design locks insert securely in place.

Design Features: Eliminates need for separate tapping operation. Will fit into Class 3 tapped hole. Built-in socket design simplifies assembly and disassembly. Provides strong working thread surface which resists high torque and tension loads.

Materials: Case-hardened cold-rolled steel, and heat-treated alloy steel.

Sizes: No. 4 to ½-in., Coarse and Fine internal threads, Class 3.

Source: Rosan Inc., Newport Beach, Calif.



Jack Nut

Form: One-piece, all-metal, threaded, blind anchor nut. Consists of metal sleeve with threaded and flanged ends separated by a slotted expander section. Sleeve is pressed into drilled hole with flange against part surface. Screw is inserted to engage threaded end. As screw is tightened, the anchor backing is collapsed against part to form blind head, locking unit firmly in place.

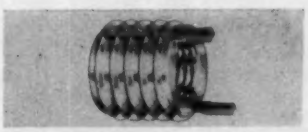
Design Features: Provides a permanent, threaded anchor for blind or open application in any material. Can be used as rivet or blind fastener, and does not require special holes.

Materials: Cadmium-plated, aluminum-killed steel; brass.

Sizes: No. 6-32 to ¼-20 screw sizes. Body styles include short length for part thicknesses up to 3/16 in. and long length for thicknesses from 3/16 to ⅜ in.

Source: Molly Corp., Reading, Pa.

(See Ad, Page 112)



Keensert Insert

Form: Single-unit, internally and externally threaded, all-metal insert with stepped keys mounted in dovetail grooves on opposite sides of external thread surface. Insert is screwed into standard tapped hole. Keys are then pressed into threads of tapped hole with a small punch and hammer or simple installation tool to lock insert in place.

Design Features: Provides strong, easily installed threaded hole in aluminum, magnesium, plastics, and other relatively soft materials. Can be installed by hand in holes tapped with standard tools. External keys provide positive resistance to insert rotation.

Materials: Passivated stainless steel, carbon steel, and chrome-moly steel.

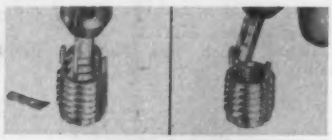
Sizes: No. 2 to 1 in.; Coarse and Fine internal threads. Body styles include closed and open ends, locking and non-locking internal threads.

Source: Newton Insert Co., Los Angeles, Calif.

(See Ad, Page 110)

Keensert Replaceable-Sleeve Insert

Form: Single-unit, all-metal, self-locking insert assembly consisting of internally and externally threaded sleeve mounted inside an internally and externally threaded shell. Insert assembly is screwed into standard tapped hole and stepped keys, which are mounted in dovetail grooves on opposite sides of external thread surface of shell, are pressed into tapped threads with simple installation



tool to lock insert in place. Sleeve is locked against rotation within the shell by a removable key that fits into mating slots in the sleeve and shell walls. To replace sleeve, key is removed, old sleeve is unscrewed, new sleeve is screwed into shell, and key is replaced. Internal threads of sleeve have either a prevailing-torque locking feature or a free-spinning type lock which grips the bolt threads in the manner of a collet when the bolt is seated to preload torque value.

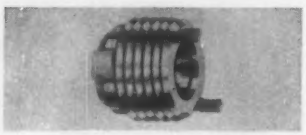
Design Features: Particularly suited for use in applications where frequent removal and reassembly of screw is expected. Provides a strong, easily installed, replaceable, self-locking threaded hole in aluminum, magnesium, plastic, and other relatively soft materials. Insert assembly can be installed by hand in holes tapped with standard tools. External keys of shell provide positive resistance to insert rotation; inner key locks sleeve securely in place.

Materials: Passivated stainless steel, carbon steel and chrome-moly steel.

Sizes: No. 10, 1/4, and 5/16 in. internal threads.

Source: Newton Insert Co., Los Angeles, Calif.

(See Ad, Page 110)



Keensert Self-Aligning Insert

Form: Single-unit, all-metal insert assembly consisting of internally threaded inner sleeve and externally threaded outer sleeve, with stepped keys mounted in dovetail grooves on opposite sides of external thread surface. Inner sleeve is held in outer sleeve by retaining ring. Insert is screwed into standard tapped hole. Keys are then pressed into tapped threads with a small punch and hammer or simple installation tool to lock insert assembly in place. Clearance between inner sleeve and outer sleeve permits internally threaded section to correct for screw misalignment. Lugs on bottom of inner sleeve seat in notches in outer sleeve to prevent internally threaded section from pulling out when screw is tightened.

Design Features: Provides a strong, easily installed threaded hole in aluminum, magnesium, plastic and other relatively soft material. Can be installed by hand in holes tapped with standard tools. External keys provide positive resistance to insert rotation. Clearance of 0.040 in. is provided between sleeves for compensation of screw misalignment.

Materials: Carbon and stainless steel.

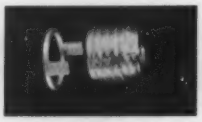
Sizes: No. 4-40 to 3/8 in. internal threads. Body styles include locking and nonlocking internal threads.

Source: Newton Insert Co., Los Angeles, Calif.

(See Ad, Page 110)

Kelox Inserts

Form: Two-piece insert assembly consisting of externally and internally threaded insert member and locking key ring. Projecting keys on surface of ring fit into mating axial grooves in upper external threads of insert. When ring is pressed into place after insert is screwed into tapped hole, keys cut through sufficient tapped threads to provide positive locking action.

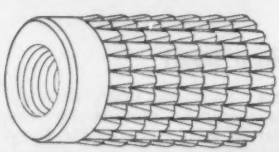


Design Features: Insert can be installed and removed with standard tools. Tapped hole is not injured when insert is removed for replacement. Internal threads can be readily adapted to several screw locking devices. Permits use of minimum edge distance.

Materials: Carbon, alloy, and stainless steels.

Sizes: No. 6 to 1/2 in.; NF or NC internal threads.

Source: Fasteners Inc., East Boston, Mass.



Knurled and Serrated Insert

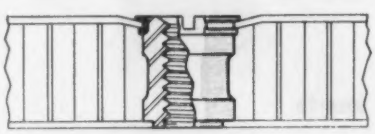
Form: Internally-threaded insert with external surface that is knurled and serrated to form hook-shaped teeth. Insert is pressed into prepared hole in soft materials in the hot or cold condition, or it is molded in place. Flow of material into knurled and serrated surface holds insert firmly in place.

Design Features: Can be installed with standard tools. Provides strong permanent tapped hole in soft or fragile materials. Angled shape of surface teeth facilitates installation but resists rotation and pullout.

Materials: Brass, aluminum, and steel.

Sizes: No. 2 to 5/8 in. internal threads. Body styles include through and blind hole types.

Source: J. B. Plevyak Mfg. Co., Newton, N. J.



Kwiko Insert

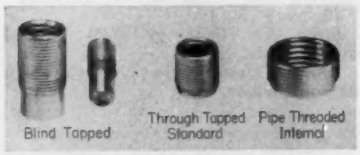
Form: Two-piece, self-locking panel insert assembly consisting of internally threaded insert and metal grommet. Insert is mounted in counterbored hole in panel and grommet forced in place. Grommet flares outward under skin surface locking insert into position. Screw driver slot is provided in end of insert for prevention of rotation when threaded fastener is being installed.

Design Features: Provides lightweight threaded hole that can carry load and prevent collapse of panel structure. No special installation tools required. Primarily used in honeycomb sandwich panels.

Materials: Aluminum.

Sizes: No. 8-32, No. 10-32, and 1/4-28 internal threads. Lengths from 3/16 in.

Source: Shur-Lok Corp., Anaheim, Calif.



Min O'Dee Insert

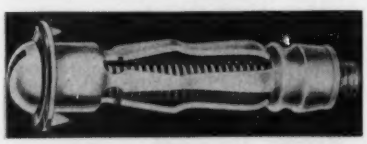
Form: Externally and internally threaded insert. External threads are modified Unified thread form for prevailing-torque locking action in standard tapped holes. Internal threads are Unified 2B form with 60 per cent thread depth.

Design Features: External threads on insert maintain secure locking action which is improved by work load and vibration. Can be installed in steel, cast iron, soft metals and plastics, and can be easily removed with a standard easy out tool.

Materials: Steel.

Sizes: No. 10 to 1 in.; Coarse and Fine internal threads. Body styles include through and blind-tapped holes.

Source: Lock Thread Corp., Detroit, Mich.



Molly Screw Anchor

Form: Single-unit, blind anchor nut consisting of metal sleeve with threaded and flanged ends separated by a slotted expander section. Sleeve is pressed into drilled hole with flange against part surface and screw is inserted to engage threaded end. As screw is tightened, slotted section expands and draws in tightly against back of part to form blind head, locking assembly firmly in place.

Design Features: Provides a permanent thread anchor in blind or open locations for sheet metals or soft materials where tapping is impractical or undesirable. Spider shape of blind head reinforces section around hole.

Materials: Aluminum-killed steel.

Sizes: No. 6-32, No. 10-24, and 1/4-20 screw threads. Grip lengths from 1/8 to 1 3/4 in.

Source: Molly Corp., Reading, Pa.

My-T-Grip Type M Insert

Form: One-piece, internally threaded, all-metal insert with recessed, knurled grooves on center portion of external surface. Insert is locked in position in suitable punched or drilled hole in sheet metal parts by cold pressing sheet material into recessed grooves with a staking die.

Design Features: Provides low-cost threaded hole in sheet materials where tapping is impractical or undesirable. Can be installed with standard hydraulic or pneumatic presses. Can be installed separately or in gangs. Provides a positive bond with sheet material in which it is installed.

Materials: Mild steel and Type 303 stainless steel.

Sizes: No. 2-56 to No. 10-32 internal threads, Class 2B. Sheet thicknesses from 0.031 to 0.250 in. Body styles include flush and shoulder types.

Source: My-T-Grip Mfg. Co., New York, N. Y.

My-T-Grip Type PS Insert

Form: One-piece, internally threaded, all-metal insert with externally grooved section at one end and wide shoulder flange at other end. Insert is molded into plastic sections or pressed into suitable hole in plastic sheet material. In pressing operation, which requires special staking dies, metal of insert flows into plastic sheet to form tight bond.

Design Features: Provides a strong threaded hole in non-flowing plastics. Can be installed with standard presses. Adaptable to high-speed production-assembly methods.

Materials: Brass or aluminum.

Sizes: No. 2-56 to No. 10-32 internal threads; Class 2B. Sheet thicknesses for pressed-in installation from 0.031 to 0.250 in.

Source: My-T-Grip Mfg. Co., New York, N. Y.

My-T-Grip Type SS Insert

Form: One-piece, internally threaded, all-metal insert with recessed knurled grooves on external surface and a stepped-shoulder at one end. Insert is pressed into suitable punched or drilled hole in sheet-metal parts, seating shoulder. Inner step in shoulder produces cold flow of sheet material into recessed grooves to lock insert in place.

Design Features: Provides low-cost threaded hole in thick or thin sheet metals or soft materials where tapping is impractical or undesirable. Can be installed on standard presses. Adaptable to high-production assembly methods. Can be installed close to edge of thin sections without distortion of base material.

Materials: Mild steel and Type 303 stainless steel.

Sizes: No. 2-56 to No. 10-32 internal threads, Class 2B. Sheet thicknesses from 0.030 in. up.

Source: My-T-Grip Mfg. Co., New York, N. Y.

Nylok Threaded Insert

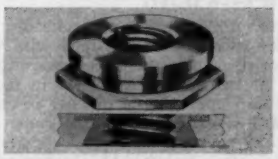
Form: Selflocking, internally and externally threaded insert. Insert is mounted in tapped hole. Radial nylon plug provides positive wedge-locking action on both internal and external threads.

Design Features: Reusable. Eliminates need for counterboring, special tapping, and secondary operations. Requires only standard screw driver for insertion or removal in hole drilled and tapped with standard tools. Nylon plug sets up lateral thrust on both internal and external threads, smoothly wedging mating threads together on both tapped member and screw without galling, thread distortion, or mutilation of mating threads. Useful temperature range under average conditions is −70 to 250 F. Used principally in nonferrous forgings, castings, and extrusions to provide strong, removable tapped hole, or in applications where bolt removal and replacement may be frequent.

Materials: Low-carbon steel.

Sizes: No. 8-32 to ⅜-24; class 3B internal threads.

Source: The Nylok Corp., Elmira Heights, N. Y.



Pem Self-Clinching Insert

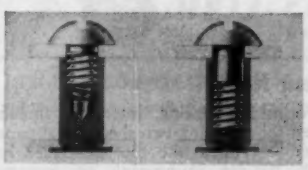
Form: One-piece, all-metal, self-clinching insert. Insert is hexagonal with round, reverse-tapered shank. Insert is pressed into prepared round hole in sheet until hex is embedded flush. Metal extruded against tapered shank locks insert in place.

Design Features: Provides high torque and push-out resistance. Is easily applied, one or several at a time, with pneumatic or oil-hydraulic squeezer, or mechanical press. Provides a flush-mounting area on both sides of sheet in which it is applied. Suitable for use in aluminum alloys, brass, copper, cold-rolled steel, and similar sheet materials in thicknesses down to 0.061 in.

Materials: 303 stainless steel.

Sizes: No. 2 to No. 10; Coarse and Fine internal threads.

Source: Penn Engineering & Mfg. Corp., Doylestown, Pa.



Pem Stand-off Fasteners

Form: Hexagonal-headed, internally threaded, cylindrical inserts with annular groove next to head. Unit is pressed into prepared hole until hexagonal head is flush with sheet. Metal extruded into annular groove locks unit in place.

Design Features: Provides rapid assembly of stand-off separators with metal panel. Facilitates "sandwich" assemblies with other metal or dielectric panels and/or individual components. Embedded hex head gives high resistance to torque. Suitable for use in materials with hardness up to Rockwell B 80 and sheet thicknesses from 0.040-in. up.

Materials: Carbon steel, 7075T6 aluminum alloy, and 303 stainless steel.

Sizes: No. 4 and No. 6; over-all lengths from ⅛ to 1 1/16 in. Body styles include blind-head and through-threaded types.

Source: Penn Engineering & Mfg. Corp., Doylestown, Pa.

Permalock Insert

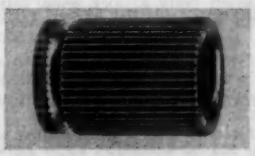
Form: One-piece, all-metal, internally threaded self-locking insert. Body of insert has external knurled collar at one end and split resilient segments at the other end. Insert is pressed into drilled hole. Knurled collar grips wall of hole to hold insert firmly in place. Resilient segments press inward to develop prevailing-torque locking action on screw members.

Design Features: Can be installed or removed with standard tools. Provides strong, permanent, self-locking threads in soft, brittle, or sheet materials. Locking action resists vibration and shock loads. Knurled collar resists rotation and pull-out forces. Standard type is used for general-purpose application in thin and heavy materials. Anchoring type is used in brittle plastics and soft materials and has external fins which are driven into hole wall for added holding power when screw enters insert. Self-riveting type is used in sheet materials of 0.020 in. thickness and greater; it is locked to sheet by split segments which open up when screw enters.

Materials: Spring-tempered medium-carbon steel, mild steel, stainless steel, brass, and aluminum.

Sizes: No. 4 to 9/16 in. nominal screw sizes; Coarse and Fine threads. Body styles include headed and headless types.

Source: J. B. Plevyak Mfg. Co., Newton, N. J.



Push-Lock Insert

Form: Internally threaded insert with straight knurls on external surfaces and special spreader section at blind end. Knurled and spreader sections are separated by annular groove. Insert is pressed into drilled or molded hole. Knurls grip wall of hole to prevent rotation. When blind end contacts bottom of hole, spreader section expands and engages hole walls to lock insert against pull out.

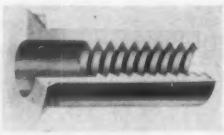
Design Features: Provides a strong threaded hole in blind locations in molded-plastic, soft-metal, and wood parts.

Can be installed with standard arbor or air press. Eliminates need for molded-in inserts.

Materials: Brass and aluminum.

Sizes: No. 2-56 to No. 10-32.

Source: Fastener Products Inc., Wilton, Conn.



Rivnut

Form: One-piece tubular blind rivet with internal threads. Force exerted by installation tool pull-up stud inserted in threaded section causes shank to expand, locking rivet in place.

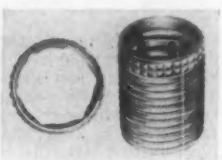
Design Features: Serves function of blind rivet and blind nut plate. At least 6 clean threads are provided for screw-on attachment. Wide bearing surface of rivet forms liquid-tight seal. Finish of enameled or plated surfaces is not marred when rivet is installed.

Materials: Aluminum, steel, stainless steel, and brass.

Sizes: No. 4-40 to ½-13 internal threads. Wide range of standard grip lengths. Head styles include flat or countersunk.

Source: The B. F. Goodrich Co., Akron, Ohio.

(See Ad, Page 109)



Rosan Slimsert

Form: Internally and externally threaded insert. External threads are modified UNF-3A thread form with serrations in the upper threads. Internally threaded section, which is counterbored at top, accommodates standard screw sizes. Internal threads are cut away to form a hexagon socket for insertion of driving tool. Insert is driven into standard tapped hole (Class 3B) and serrated thread section is swaged into the part material to lock insert in place. Fine internal-thread designs have prevailing-torque locking feature at center of insert body to lock screw fasteners.

Design Features: Provides strong, thin-walled, locked-in thread surface in thin sections and soft materials. Built-in socket design simplifies assembly and disassembly. Locking feature with fine internal-threads is reusable.

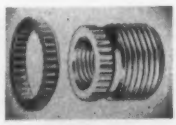
Materials: 17-4 PH stainless steel.

Sizes: No. 10 to ½ in., UNF and UNC (modified) threads, Class 3B.

Source: Rosan, Inc., Newport Beach, Calif.

Rosan Threaded Insert

Form: Two-piece all metal insert assembly consisting of internally and externally threaded insert and serrated locking ring. Insert is mounted in counterbored tapped hole and locked in position by locking ring. Serrated teeth on ring ID engage mating teeth on collar of insert while teeth on ring OD broach



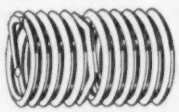
their way into counterbored surface when ring is driven or pressed into place.

Design Features: Requires only Class 3 tapped hole for installation. External threads on insert have special pitch diameter which produces interference locking fit in tapped hole. Resists loosening effect of vibration, high stress, and temperature change. Insert installation does not distort or stress part material, and does not require special tools. Can provide effective sealing against hydraulic or pneumatic pressure. Used to provide durable steel tapped hole in all types of materials.

Materials: Insert is steel; locking ring is case-hardened low-carbon steel.

Sizes: No. 4 to 1 in.; Coarse and Fine internal threads. Body styles include several modified forms of basic insert.

Source: Rosan Inc., Newport Beach, Calif.



Screw-Lock Insert

Form: Precision-formed coil of 18-8 stainless steel diamond-shaped wire with one or two polygon-shaped constricting loops at center. When seated in tapped hole, coil provides standard 60-degree threads. Constricting loops at center produce locking action.

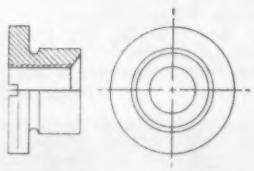
Design Features: Provides high-strength, permanent threads with built-in locking action. Resists extreme temperature variations and frequent assembly and disassembly. Insert diam is slightly oversize; when wound into properly tapped hole, coil locks in place and will withstand severe vibration loads without loosening. Reusable.

Materials: Stainless steel wire with ultimate tensile strength of 200,000 psi.

Sizes: No. 4 to 1-in. NC and UNC internal threads; No. 6 to 1-in. NF and UNF internal threads. Lengths from 1½ to 2 diameters.

Source: Heli-Coil Corp, Danbury, Conn.

(See Ad, Page 107)



Shear Nut

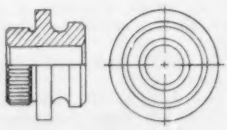
Form: Self-locking, internally threaded insert for fastening two sheet-metal panels. Insert is pressed into through-drilled hole with 100-deg countersink on one end. Shank deformation at collar of insert develops locking action when 100 deg flathead screw is installed.

Design Features: Provides close-tolerance joint with high-shear strength and moderate tensile strength. Can be installed with one or both surfaces flush.

Materials: C-1137 Steel.

Sizes: No. 8-32, NC-3B internal threads.

Source: Shur-Lok Corp., Anaheim, Calif.



Shur-Lok Spline Nut

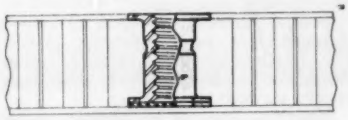
Form: One-piece, all metal, self-locking, internally threaded insert with external splines on bottom section. Insert is pressed into drilled hole. Splines cut mating splines in hole wall to lock insert in place. Deformed shank at collar of insert develops prevailing-torque locking action when screw is installed.

Design Features: Provides strong, self-locking, threaded hole for fastening sheets or bars together, or for attaching brackets to plates or structural shapes. Generally used in soft metals such as aluminum and magnesium alloys where a regular hex nut lacks space for wrenching, or where an attached nut is required.

Materials: Steel

Sizes: No. 8 to ½ in.; NC, NF, and UNF internal threads; Class 3B.

Source: Shur-Lok Corp., Anaheim, Calif.



Shur-Lok Insert

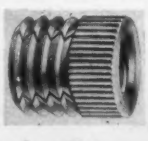
Form: Self-locking internally threaded panel insert. Insert is mounted in hole drilled in one face of panel and molded in place flush with top surface. Locking action is provided by shank deformation at center of threaded portion.

Design Features: Provides strong threaded blind hole in built-up, lightweight panel structures. Locking action meets MIL-N-25027 requirements. Used primarily in sandwich-type panels.

Materials: Aluminum, steel, and stainless steel.

Sizes: No. 8-32, No. 10-32, and ¼-28 internal threads. Grip lengths up to 2½ times bolt diameter.

Source: Shur-Lok Corp., Anaheim, Calif.



Southco Anchor Nut

Form: Slotted, internally threaded self-locking insert. External surface is barbed at slotted end and serrated at other end. Insert is driven into hole and expanded, engaging barbs and serrations with hole wall to hold insert securely in place. Threads provide positive gripping action to lock screw attachments in place.

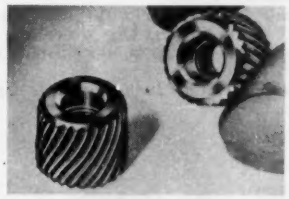
Design Features: Provides strong, permanent threaded hole for machine screws. Part surface is not marred during installation. Used to provide permanent tapped

hole in soft material where frequent assembly or disassembly of threaded members may be necessary.

Materials: Steel and aluminum.

Sizes: No. 6 to 5/16-in.; Fine and Coarse internal threads. Lengths vary with thread size.

Source: South Chester Corp., Southco Div., Lester, Pa.



Southco Insert

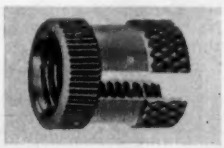
Form: Internally threaded insert with knurled external surface. Insert is pressed or driven into drilled or molded hole. Spiral knurls grip wall of hole to hold insert firmly in place.

Design Features: Provides a strong threaded hole in blind or open locations in soft or fragile materials. Design of spiral knurls resists torque and pull-out forces.

Material: Steel.

Sizes: No. 1 to 5/16-in., NC and NF internal threads; Class 2.

Source: Southco Div., South Chester Corp., Lester, Pa.



Taper-Thread Insert

Form: Slotted, internally threaded self-locking insert. External surface has diamond knurls at slotted end and straight knurls at other end. Internal threads are tapered inward toward blind end. Insert is placed in molded or drilled hole. Entrance of screw expands slotted section, driving knurls into hole wall to hold insert in place against rotation or pull-out. Straight knurls prevent top of insert from dropping below surface of hole and also prevent insert from turning as screw enters tapered threads. Radial inward pressure of insert provides gripping action to lock screw attachment in place.

Design Features: Provides strong self-locking threads in blind or through holes in molded-plastic, soft-metal, or wood parts. Expansion of internal threads and, thus, locking action of insert is controlled by varying diameter of mounting hole. Can be inserted manually or by machine. Eliminates need for molded-in inserts.

Materials: Brass and aluminum.

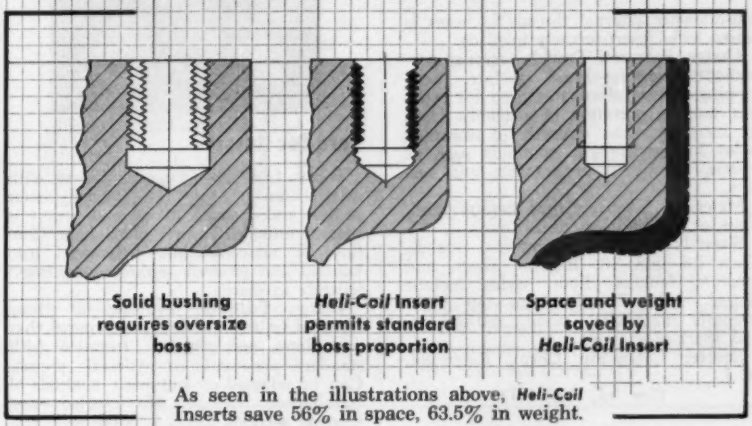
Sizes: No. 2-56 to No. 10-32.

Source: Fastener Products Inc., Wilton, Conn.

Tap-Lok Insert

Form: Internally and externally threaded bushing. Internal threads accommodate standard screw sizes; external threads are self tapping for driving into drilled or cored hole. Interference fit produced with

How You Can Save Boss Space and Weight in Thread Design ...with HELI-COIL® Inserts

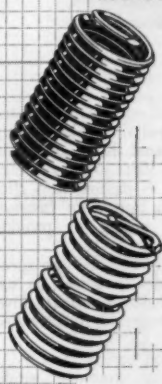

Solid bushing requires oversize boss
Heli-Coil Insert permits standard boss proportion
Space and weight saved by Heli-Coil Insert

As seen in the illustrations above, *Heli-Coil* Inserts save 56% in space, 63.5% in weight.

Heli-Coil stainless steel wire inserts have a smaller outside diameter than any solid bushing. Therefore, with ***Heli-Coil*** Inserts you can design boss radii to a minimum, yet stay with standard boss configurations. This means *savings in space and weight,* and material-savings as well.

This feature is vitally important for miniaturization in aerospace design, in electrical and electronics equipment design, and for general industrial applications.

NO OTHER TYPE OF INSERT OFFERS SUCH SAVINGS!



Heli-Coil Screw-Thread Insert

Permanently protects threads against wear, stripping, corrosion, galling, seizing, vibration and shock. Made of 18-8 stainless steel wire, cold-formed into a diamond-shaped cross section, work-hardened to a tensile strength of approximately 200,000 psi. Conforms to mil specs and all commercial and industrial thread forms.

Heli-Coil Screw-Lock Insert

Provides same protection as Screw-Thread Insert, PLUS an exclusive *patented* resilient *internal* locking feature that eliminates protruding lock nuts, lock wiring and other supplementary locking devices, thus saving additional space and weight. Meets military specifications for locking torque and vibration.

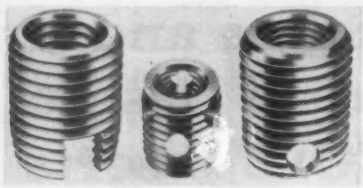
The Heli-Coil line of products includes: inserts and related taps, tools and gages. Tables of boss radius and weight comparison are available.

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 905 Shelter Rock Lane, Danbury, Connecticut
I'd like more information on *Heli-Coil* Screw-Thread Inserts ☐ Screw-Lock Inserts ☐
NAME _____ TITLE _____
FIRM _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____ 2565

In Canada: ARMSTRONG BEVERLEY ENGINEERING LTD.
6975 Jeanne Mance St., Montreal 15, Que., Crescent 4-3538

Circle F-1 on Page 97



full-diameter external threads as insert is seated locks insert securely in place.

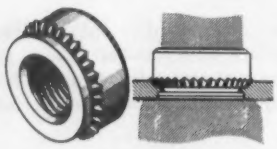
Design Features: Provides strong, permanent, working-thread surface. Self-tapping feature eliminates need for separate tapping operation in assembly. Used to increase shear strength of threaded holes in low-strength materials such as plastic, aluminum, magnesium and cast iron.

Materials: Case-hardened carbon steel, brass, or 18-8 stainless steel.

Sizes: No. 2 to ¾ in. internal threads, Class 2B and 3B. Regular, short, and medium lengths. Body styles include slotted, hole (for hard to tap high-strength materials), wood, self-locking, and spark-plug types.

Source: Groov-Pin Corp., Ridgefield, N. J.

(See Ad, Page 111)



Threds

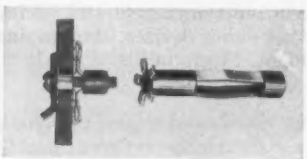
Form: Internally threaded, sheet-metal insert with knurls on bottom seating face. Insert is pressed into drilled or punched hole in thin sheet. Knurls bite into base material, anchoring insert.

Design Features: Provides a strong, permanent thread anchor for thin sheet-metal parts. Self-anchoring and torque-resisting. Can be installed without special tools. Penetration of knurls in base material is 0.015 to 0.020 in.

Materials: Case-hardened steel.

Sizes: No. 6-32 to ¼-28, NC and NF threads. Lengths from 5/32 to 3/16 in.

Source: Southco Div., South Chester Corp., Lester, Pa.



Toggle-Screw Anchor

Form: One-piece, all-metal, blind screw anchor consisting of metal sleeve with threaded and flanged ends separated by collapsible strips. Sleeve is pressed into a drilled hole and flange is seated against part surface. When screw is engaged with threaded end of anchor and tightened, center strips collapse against back of part to form blind head, locking assembly securely in place.

Design Features: Provides a permanent thread anchor in blind or open locations in thick or thin panel sections. Does not require special assembly tools. Can be adapted to high-speed assembly methods.

Materials: Steel or brass.

Sizes: No. 8-32, No. 10-24, and ¼-20 screw threads. Grip lengths from 0 to 1¾ in. Body styles include two and four-wing types.

Source: Produced by several manufacturers. Illustration, courtesy Ackerman-Johnson Co., Chicago, Ill.

Torq-Loc Insert

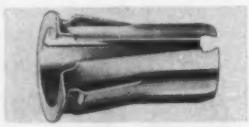
Form: Internally threaded insert with external surface that has knurled center section and grooves at one end. Insert is pressed into drilled or molded hole. Cold flow of material from hole wall into knurled and grooved sections locks insert securely in place.

Design Features: Provides a strong threaded hole. Suitable for any metal that cold flows, and plastics. Installed with standard pneumatic or hydraulic presses. Can be adapted to automatic methods of installation. Design of knurled and grooved sections forms a bond with material of hole wall to develop high holding power.

Materials: Case-hardened, cold-rolled steel and Type 416 stainless steel.

Sizes: No. 4 to ¼ in., Coarse and Fine internal threads. Length is ⅜ in.

Source: Bergen Laboratories Inc., Torq-Loc Div., Paterson, N. J.



Tubular Clips

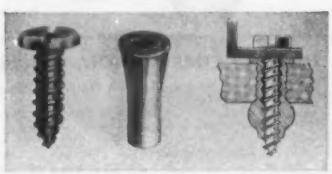
Form: One piece, all-metal locking insert for unthreaded parts. Tubular clip is inserted into prepared hole and held in position by cam-like prongs. Unthreaded stud or rivet is pushed into clip. Turned-in end of clip bites into fastener surface under spring action to provide secure lock.

Design Features: Adaptable to high-speed assembly methods. Ideally suited to use in blind locations. Used to provide low-cost locking blind fastener for unthreaded parts.

Material: Heat-treated spring steel.

Size: 1/16 to ¾-in. diameter studs. Body styles include round, rectangular, and oval-shaped.

Source: Tinnerman Products Inc., Cleveland, Ohio.



Wally Screw Anchor

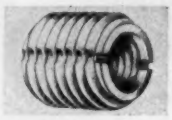
Form: One-piece screw anchor consisting of plastic sleeve with flange head and four gripper-fins to prevent sleeve from turning during assembly. Sleeve is inserted in predrilled hole, then screw is driven in. As screw is drawn up tight, sleeve bulges against back of part surface or expands inside hole to lock in place.

Design Features: Provides a secure, low-cost, easily installed screw anchor for blind or open locations in thin or thick sections. One sleeve size can be used with different size screws.

Material: Tenite.

Sizes: No. 6 to No. 10 sizes, sheet-metal screw threads. One sleeve size for ¼ in. diam by ⅞ in. deep (solid materials) hole.

Source: Holub Industries Inc., Sycamore, Ill.



Weg Insert

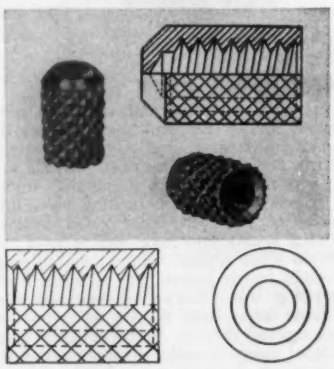
Form: Internally and externally threaded insert designed to be mounted in tapped hole. External thread surface is grooved to admit locking pins which are driven into base of tapped hole to lock insert.

Design Features: Provides strong, six-thread fastener attachment. Increases thread pull-out strength and wear resistance in soft materials. Anchor strength limited only by strength of part material. When cast in molded plastic, external grooves automatically provide locking device. Sizes under ¼-in. can be installed with screwdriver.

Materials: Carbon or stainless steel.

Sizes: No. 0 to 1 in., Coarse and Fine internal threads; Class 2.

Source: Airaterra, Glendale, Calif.



Yardley Inserts

Form: Internally threaded insert with knurled external surface. Insert is designed to be molded into plastic, rubber, and ceramics. Holes are tapped and reamed to close tolerances. May be used with or without locating pins on the die.

Design Features: Insert provides a strong, permanent threaded hole in materials where tapping is impractical or impossible. Coarse knurl provides high holding power against torque loads.

Materials: Aluminum and brass.

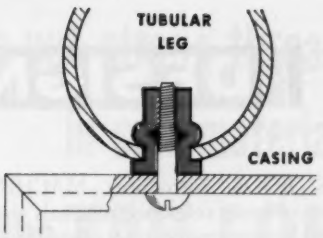
Sizes: No. 4-40 to ¼-28 internal threads, Class 2. Body styles include through threaded, closed end, and closed end countersunk.

Source: Yardley Precision Products Co., Yardley, Pa.

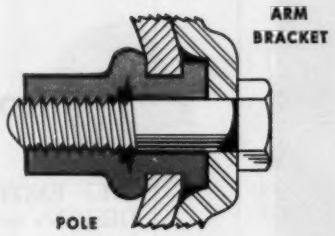
(See Ad, Page 112)

B.F.Goodrich

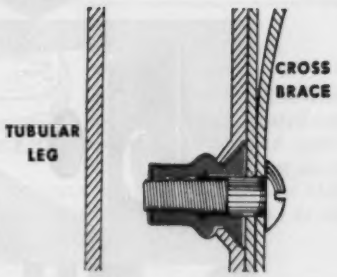
Only B. F. Goodrich Rivnuts® solve all these fastening problems so well



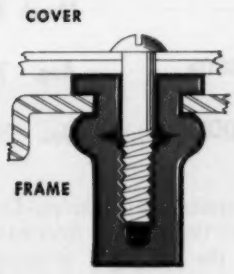
One man installs Rivnuts from one side in seconds—speeds assembly of *barbecues*. Permanent nutplates in legs save time in faster knockdown, too.



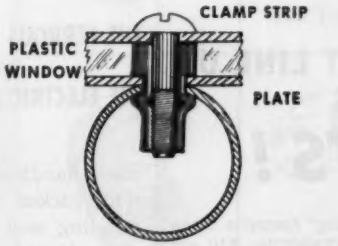
One man does the work of two, assembling arm brackets on *light poles*. Tests show pole or arm will fail before Rivnuts.



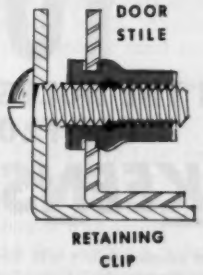
Clean, functional lines of modern *furniture* are preserved by Rivnuts. Upset inside tubular legs, they replace unsightly nuts, bolts and screws.



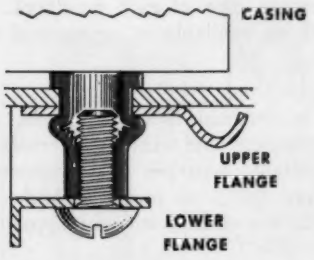
Rivnuts enable repair men to remove top of *automatic washer* and replace it easily. And Rivnuts can be installed after enamelling.



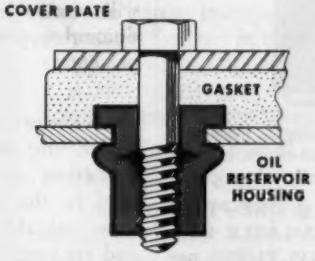
Upset Rivnuts secure *airplane window* plate to center post. Bulges in shanks seal out weather. Heads of Rivnuts serve as spacers for plastic window.



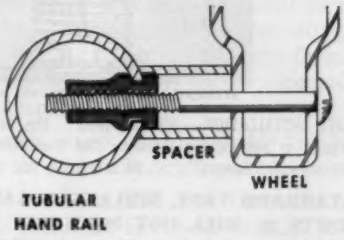
Rivnuts replace self-tapping screws used to hold retaining clips on aluminum *storm doors*, provide firm nutplates that won't loosen with shock or vibration.



Rivnuts eliminate need for reinforcing plates in *vaporizers*. In addition, Rivnuts space bottom flange automatically, prevent bending.



Assembly time for *oil reservoirs* is cut in half. Rivnuts eliminate welding, tapping and cleaning previously required to attach coverplate.

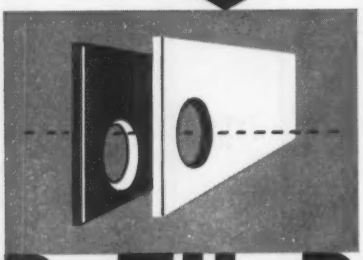


Wheel chair designers needed a blind nutplate with at least 6 clean threads. Rivnuts, only one-piece blind rivets with threads, were the answer.

Special fastening problems? B. F. Goodrich Rivnuts solve them. Send for free data book. Dept. MD-9, B. F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Akron, Ohio.

B.F.Goodrich *aviation products*

DON'T LET THIS



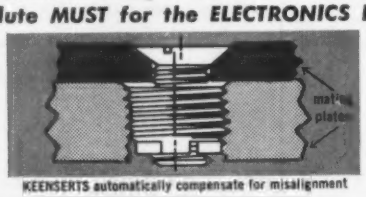
BOTHER YOU!

WHEN THE HOLES DON'T LINE UP USE FLOATING

KEENSERTS®!

You can save valuable dollars with these new **"floating"** Keenserts...they **automatically compensate** for misalignment (up to 0.040" for #10 and larger sizes). Available in 4-40 to 5/16-24 internal thread sizes.
Check how new "floating" Keenserts can reduce **your** manufacturing and assembly costs. Write for catalog "C" TODAY!

An Absolute MUST for the ELECTRONICS Industry!



KEENSERTS automatically compensate for misalignment

EASY INSTALLATION—All Keenserts...the new "floating"...those with regular or self-locking threads...the miniature and sub-miniatures...and the standard Keenserts*...all are easily and quickly installed using:

STANDARD TAPS, DRILLS and GAUGES ■ ONE-PIECE UNITS ■ WILL NOT PULL OUT ■ AVAILABLE from STOCK ■ Lock Bolts Entered ONLY A FEW TURNS per MIL-N-25027 ■ Have Positive Lock Against Rotation!

*Standard Keenserts are stocked in internal thread sizes #2 through ½". Short delivery for special requirements up to 1 inch internal threads.

Call or wire your inquiry COLLECT TODAY!

NEWTON INSERT COMPANY
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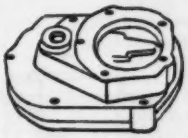
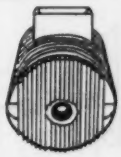
The quickest most practical way to put strong threads in soft materials the TAP-LOK® INSERT

FOR SOFTER METALS AND PLASTICS . . .
Slotted TAP-LOK insert has full V-form external threads to provide maximum locking torques; permits wide choice of mating hole sizes. Recommended for soft aluminum, zinc die castings, sand castings, and plastics. Meets requirements of MIL-MS 35914.

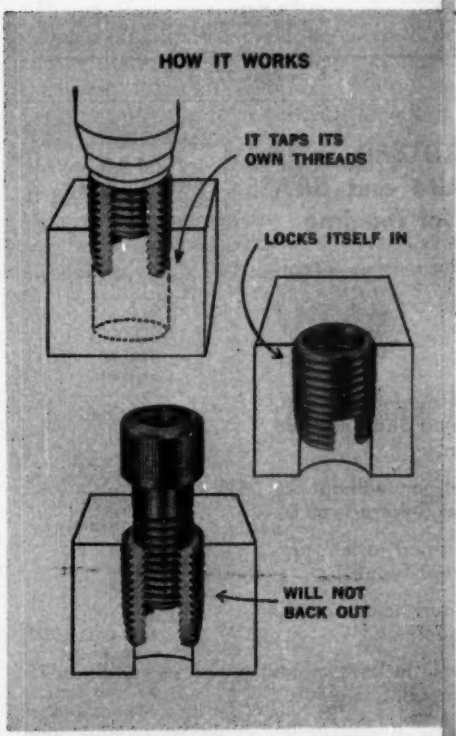


FOR HIGHER STRENGTH MATERIALS . . .
H-Series heavy-walled TAP-LOK insert has truncated root external thread and three-hole cutting edges for hard-to-tap higher strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation.



FOR SPARK PLUG SOCKETS . . .
P-Series TAP-LOK insert was designed to eliminate thread wear and renew damaged threads in spark plug sockets in aluminum cylinder heads. Available from stock for standard plug sizes to meet most needs.

FOR WOOD . . .
W-Series TAP-LOK insert has coarse pitch external thread offering maximum strength in combination with ability to be driven into thin sections without splitting them. For furniture, cabinets, and other wooden parts where strong, permanent threads are needed, or which must be frequently assembled and disassembled.



The TAP-LOK® threaded insert taps its own thread and locks itself into the parent material in a single, quick operation. Designed as a permanent fastener in materials which are machinable but not strong enough to sustain applied loads in threads tapped directly into them, it is also widely used in harder metals and alloys where repeated assembly makes thread wear a problem.

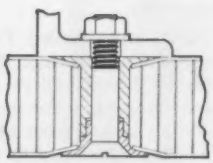
Since TAP-LOK cuts its own threads, no additional assembly time is required, *making its installed cost the lowest of any threaded insert!*

Once installed, it is permanently locked in place, and will not back out under repeated heavy shocks or prolonged vibration. TAP-LOK inserts are available in the types shown at the right, in a variety of metals that include casehardened carbon steel, brass and 18-8 stainless steel (type 303). For complete information and prices, write Groov-Pin Corporation, 1130 Hendricks Causeway, Ridgefield, N. J.

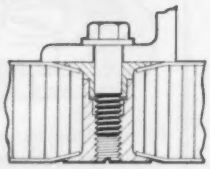
TAP-LOK *Another fastener development from—* **GROOV-PIN CORPORATION**

HONEYCOMB
and
sandwich panel
FASTENERS
PATENT PENDING

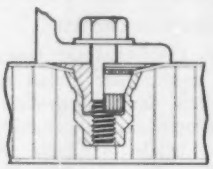
by Delron



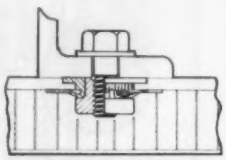
GROMMET FASTENER
Series 101 and 102
Thru-Rivet and Thru-Bolt Type



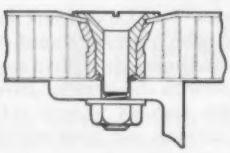
GROMMET FASTENER
Series 103
Series 104 (Self-Locking)



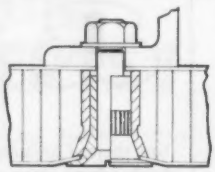
BLIND FASTENER
Series 293
Internal Thread Blind Type



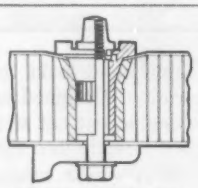
BLIND FASTENER
Series 293K
Threaded Clutch Type



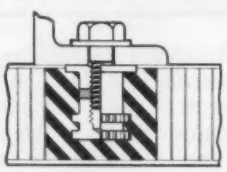
STRUCTURAL FASTENER
Series 600 Flared
Thru-Rivet and Thru-Bolt Type



STRUCTURAL FASTENER
Series 600 Regular
Thru-Rivet and Thru-Bolt Type

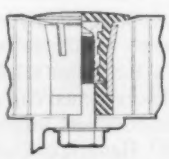


STRUCTURAL FASTENER
Series 700
Floating Locknut Type



MOLDED-IN INSERT
Series 404H
Blind Molded-in Type

Illustrated are only a few of the many available types of Delron Sandwich Panel Fasteners. Write for complete Technical Data.



STRUCTURAL PLASTIC FASTENER
Series 680
Internal Thread Type

THE DELRON COMPANY, INC.
5224 Southern Ave., South Gate, Calif. • LOrain 7-2477
Largest Manufacturer of Specialized Sandwich Panel Fasteners

Circle F-5 on Page 97

MOLLY®

JACK NUT®

The Only Blind Fastener Which Grips Any Material From 0" To ⅜" Thick

The Jack Nut cuts cost, speeds assembly, solves hitherto impossible fastening problems. Can be used as a rivet and/or blind fastener. It's versatile, easy to use and no special tools are needed.

The only blind fastener with threads which grips any material from 0" to ⅜" thick. Needs only ⅛" expansion space. Allows holes to be fashioned before, during or after fabrication. Hole size is not critical and special type of hole is not necessary.

Made of quality steel, cadmium-plated. Grips evenly on rough as well as smooth surfaces. Provides vibration-proof assembly. Weight-carrying capacity is limited in most cases only by strength of the material in which used.

Sold By Wholesale Hardware, Electrical Wholesale & Industrial Supply Distributors

MOLLY® CORP.
246 N. 5th St., Reading, Pa.

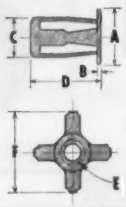
EASY TO INSTALL

1 Insert Jack Nut into hole. Needs only ⅛" expansion space.

2 Run in screw to collapse spider anchor backing by exerting pull on thread.

3 Jack Nut now is installed and ready to receive attachment screw.

SPECIFICATIONS



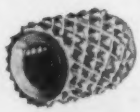
	CAT. NO.	A CAP DIA.	B CAP THICK.	C BODY DIA.	D O'ALL L'GTH.	E THREAD	F MAX. SPREAD
	4-S, JN	15/32	3/64	9/32	9/16	6-32	43/64
	4-L, JN	15/32	3/64	9/32	3/4	6-32	43/64
*	6-S, JN	17/32	1/16	3/8	11/16	10-24	25/32
**	8-S, JN	5/8	1/16	27/64	3/4	¼"-20	13/16

S for 0" to 3/16"; L for 3/16" to ¾"
*8-32 & 10-32 threads available
**10-24 & 12-24 threads available
NOTE: 4-S, JN & 6-S, JN also available in brass

Circle F-6 on Page 97

STANDARDIZED ALUMINUM and BRASS INSERTS for molding

into
PLASTICS
RUBBER
CERAMICS

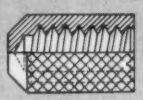


- Precision made in plain, brass plated and anodized aluminum.
- Used with or without locating pins (except Type D).
- Holes reamed after tapping (except Type D).
- Coarse knurl holds against high torque.
- Ample wall thickness holds against molding pressure.

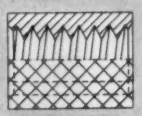
Large and small quantities available from stock.

Write for Data Sheets and Prices

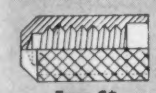
A.S.M.E. Class 11 Threads from 4-40 to 1/4-28



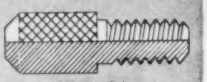
Type A*
Closed End



Type B*
Through Threaded



Type C*
Closed End with Countersunk Hole



Type D*
Threaded Stud

* Patent Pending

YARDLEY PRECISION PRODUCTS CO.
26 E. AFTON AVE., YARDLEY, PA.

Circle F-7 on Page 97

CHAPTER

22 Nuts

NUTS can be classified into two principal types: Nonlocking and locking. Properly tightened, a nonlocking nut will usually not loosen, providing sufficient pressure is maintained between the threads, at the nut, and at the bolt-head seat. Under vibration or impact, where the pressure fluctuates, loosening may occur unless some locking device is employed. Locknuts offer two principal types of locking action. Prevailing-torque (sometimes called self-locking) locknuts provide a continuous gripping action when the locking device is engaged with bolt thread. They can usually be employed as either a seated locknut or a stop nut. Free-spinning, or load-locking, lock nuts require a base load to develop locking action. They can usually be employed only as a seated locknut, although some types, which incorporate a load-locking member, can also be used as stop or adjusting nuts.

Nonlocking Nuts

Allenut

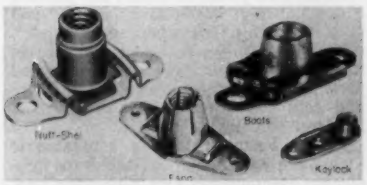
Form: All-metal, dual-purpose nut that can be used as internal-wrenching nut or thread insert. One end has internal 12-point socket for wrench tightening, while other end is internally threaded. External knurled collar permits anchoring of nut in counterbored hole for use as insert.

Design Features: Provides hardened tapped hole in castings or soft materials, or compact wrenching nut for machine assemblies. Can be pressed or molded into preassembled parts. Length of thread engagement is same as for conventional medium-weight nut. Can be readily removed and replaced in insert application.

Materials: Hardened and tempered alloy steel.

Sizes: No. 4 to 1 in.; NC and NF threads.

Source: The Allen Mfg. Co., Hartford, Conn.



Anchor (Plate) Nuts

Form: Nut with lug projections for permanent mounting to work. Nut and lugs may be integral, or cage-type construction may be employed with nut rigidity attached or floating. Nut is mounted by welding, riveting, or other methods.

Design Features: Provides a permanent nut attachment for assembly of threaded fastener elements in blind or open locations. Shape of lugs can be modified to fit application. Eliminates danger of loose nut becoming lodged in mechanism.

Materials: Steel, corrosion-resistant steel, and aluminum.

Sizes: No. 4 to ⅝-in.; Coarse and Fine threads, Class 2B and 3B. Ranges vary with manufacturer Nut types include nonlocking and self-locking. Body styles include fixed and floating one lug, two lug, triangular, gang, and others.

Source: Produced by several manufacturers. Illustrations, courtesy (Boots) Boots Corp., Norwalk, Conn.; (Esna) Elastic Stop Nut Corp of America, Union, N. J.; (Kaylock) Kaynar Mfg. Co. Inc., Los Angeles, Calif.; (Nutt-Shel) Aircraft/Missile Div., Standard Pressed Steel Co., Jenkintown, Pa.

Castle (Castellated) Nuts

Form: Hexagon nut with a cylindrical crown through which slots are milled. Cotter pin or safety wire inserted in drilled hole in bolt can be used to lock nut in place.

Design Features: General-purpose nut that can be readily adapted to provide locking features. Provides solid hexagon base, since slots are located in crown.

Materials: Steel, brass, aluminum, and other standard materials.

Sizes: ¼ to 1½-in., Coarse and Fine threads; Class 2B.

Source: *American Standard Square and Hexagon Bolts and Nuts*—ASA B18.2-1955. Photo, courtesy Standard Screw Co., Bellwood, Ill.

(See Ad, Page 132)

CIP Multi-Thread Nuts

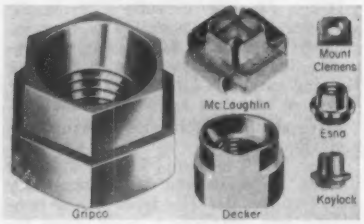
Form: One-piece, all-metal, clip-on nut consisting of a J or U-shaped clip with a multiple-threaded round-nut body. Clip slips on over edge of panel or thin section.

Design Features: Provides heavy duty nut member that does not have to be held in place when bolt is assembled. Used on panels or thin sections where edge fastening is required. Conical base acts as guide for pilot of screw, reducing danger of cross-threading.

Materials: Heat-treated high-carbon steel.

Sizes: No. 10 to ⅜ in.; Coarse and Fine threads. Body styles include locking and nonlocking types.

Source: California Industrial Products Inc., South Gate, Calif.



Clinch Nuts

Form: Threaded nut with pilot-type projection on bottom face. Nut is seated on sheet-metal part or thin section with pilot mounted in prepared hole. End of pilot is clinched to lock nut in place.

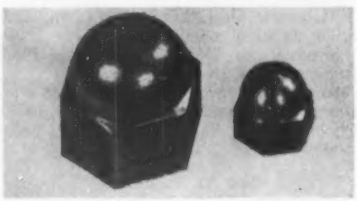
Design Features: Provides a permanently attached nut for assembly of threaded fasteners in blind or open locations. Adaptable to high-speed assembly methods. Can be used with metals difficult to weld, with sheet-metal parts or materials where tapping is impractical, or with prefinished parts.

Materials: Steel, brass, and aluminum.

Sizes: Most standard nut sizes; Coarse and Fine threads. Body styles include square, hex, round, floating, and others.

Source: Produced by several manufacturers. Illustrations, courtesy (Decker) Decker Nut Mfg. Co., Albion, Mich.; (Esna) Elastic Stop Nut Corp. of America, Union, N. J.; (Gripco) Grip Nut Co., South Whitley, Ind.; (Kaylock) Kaynar Mfg. Co. Inc., Los Angeles, Calif.; (McLaughlin) McLaughlin Co., Birmingham, Mich.; (Mount Clemens) Mount Clemens Metal Products Co, Mount Clemens, Mich.

(See Ads, Pages 121, 127)



Crown (Blind, Acorn) Nuts

Form: Hexagon nut with crown cap.

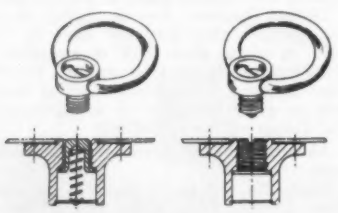
Design Features: Provides sealing protection for projecting threaded parts. Gives a neat, finished appearance.

Materials: Steel, brass, zinc, aluminum, and other materials.

Sizes: No. 6 to 1¼ in.; Coarse and Fine threads. Styles include high and low crowns.

Source: SAE Recommended Practice, 1960 *SAE Handbook*. Photo, courtesy Anti-Corrosive Metal Products Co. Inc., Castleton-on-Hudson, N. Y.

(See Ad, Page 132)



Davis Blind Fasteners

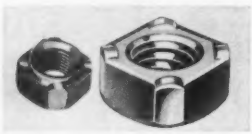
Form: Single-unit, receptacle-nut assembly consisting of flanged type nut with spring-loaded or threaded sealing plug. Pilot collar on base of nut is inserted in prepared hole in panel and flange is fastened in place by screws, rivets, or welding.

Design Features: Provides a plugged receptacle for threaded studs. Type with spring-loaded plug can be used with standard threaded parts. Threaded plug is slotted to engage screw-driver tip on mating threaded part.

Material: Steel.

Sizes: No. 10 to 1 in. nominal thread sizes.

Source: Davis Aircraft Products Inc., New York, N. Y.



Decker Weld Nuts

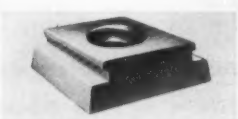
Form: Square nut with pilot shoulder and four projections on bottom face; corners are chamfered. Pilot shoulder is inserted into prepared hole and nut is projection-welded into place.

Design Features: Provides a low-cost, rapidly assembled nut or tapped hole. Designed primarily for use with carbon steel parts; but can be used on nonferrous metals and alloys. Pilot is narrower than the thickness of part to which nut is welded, allowing welding without the part extending through parent material. Can be adapted to high-speed feeding devices and machine assembly methods. Pilot design facilitates positioning of nut in assembly.

Material: Steel.

Sizes: No. 6 to ⅝ in.; Coarse and Fine threads, Class 2B. Body styles include square and hex designs without pilot shoulders for use where hole is not desired in base metal.

Source: Decker Nut Mfg. Corp., Albion, Mich.



Fabristeel Pierce Nut

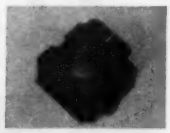
Form: One-piece, all-metal, self-piercing clinch nut. Nut has rectangular head and pilot-type projection separated by undercut section. Hardened face of pilot pierces its own hole when pressed against metal part surface. Impact against die snaps and cold works metal into undercut to lock nut securely in place.

Design Features: Readily adaptable to high-speed continuous or batch-type production assembly methods. Eliminates need for separate hole punching operation. Can be installed on metal sections from 0.025 to 0.125-in. thick. Provides a permanently attached nut for assembly of threaded fasteners in blind or open locations. Offers high resistance to vibration and tension or shear loads. Can be used as a conventional clinch nut on parts with prepared holes.

Materials: Work-hardened steel body with piercing surface of over Rockwell 100 B hardness.

Size: No. 6 to ⅜-in.; Coarse and Fine threads.

Source: Fabristeel Products Inc., Detroit, Mich.



Flex Nut

Form: Single-unit, all-metal, nut assembly combining a standard nut and a spring steel cage. Resilient cage is assembled to a square hole in a panel section, and retainer is locked into position by the screw.

Design Features: Provides a snap-in female thread in mid-panel areas where it is impractical to use other types of fasteners.

Material: Steel.

Sizes: No. 6 to ½ in.; Coarse and Fine threads.

Source: Prestole Corp., Toledo, Ohio.

GRC Tamperproof Cap Nut

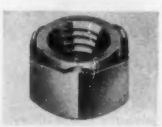
Form: One-piece, all metal, threaded nut with wide washer base. Sides of nut are sharply tapered from base to top, and base has three notched recesses to accommodate a special wrench.

Design Features: Provides a smooth headed nut which conceals the end threads of axles. Head design requires a special wrench for installation, and prohibits cannibalizing of wheels. Wide base design provides integral washer and hole in top of nut provides lubrication hole.

Materials: Die cast zinc alloy.

Sizes: Nut is 9/16-in. high with No. ½-13 threads.

Source: Gries Reproducer Corp., New Rochelle, N. Y.



Gripco Weld Nut

Form: All-metal hex-body nut with three or six weld projections and pilot collar on bottom surface. Nut is projection welded to part surface.

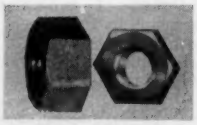
Design Features: Provides a permanent nut attachment for steel stampings or other parts where threaded hole is impractical. Pilot collar design facilitates assembly in prepared hole without special jigs. Collar prevents fouling of threads by weld spatter.

Materials. Mild steel.

Sizes: No. 4 to ⅝-in.; Coarse and Fine threads. Body styles include countersunk seat as well as locking and nonlocking types.

Source: Grip Nut Co., Chicago, Ill.

(See Ad, Page 127)



Hexagon Nuts

Form: One-piece, standard threaded nut.

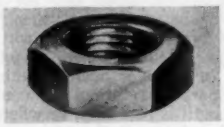
Design Features: General-purpose nut. Finished series is designed for average use. Heavy series is thicker and wider and is suitable for use with heavy loads and large bolt clearances.

Materials: Steel, brass, aluminum, sintered brass, nylon, and other standard materials.

Sizes: ¼ to 4 in.; Coarse, Fine, and 8-thread series; Class 2B. Body styles include regular, regular semifinished, finished, heavy, and heavy semifinished.

Source: *American Standard Square and Hexagon Bolts and Nuts*—ASA B18.2-1955. Photo, courtesy Anti-Corrosive Metal Products Co. Inc., Castleton-on-Hudson, N. Y.

(See Ads, Pages 123, 127, 132, 140)



Jam Nuts

Form: Thin standard hexagon nut.

Design Features: Used primarily on bolts subjected to shear, rather than tensile loading, where strength of full nut is not required. Can also be used in pairs, or with plain nuts to provide locking action.

Materials: Steel, brass, and other materials.

Sizes: ¼ to 4 in.; Coarse, Fine, or 8-thread series; Class 2B. Body styles include regular, regular semifinished, heavy semifinished, and finished.

Source: *American Standard Square and Hexagon Bolts and Nuts*—ASA B18.2-1955. Photo, courtesy The H. M. Harper Co., Morton Grove, Ill.

(See Ads, Pages 123, 132, 140)

Johnson Weldnut

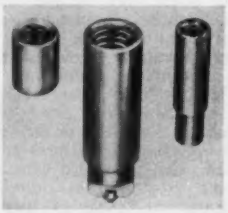
Form: Square nut with four upset weld projections on lower surface. Nut is projection welded in place.

Design Features: Provides permanent nut attachment for parts where tapped hole is impractical.

Material: Low-carbon steel.

Sizes: ¼ to ⅝-in.; all standard threads. Body styles are regular and heavy square.

Source: Produced under license by National Screw & Mfg. Co., Cleveland, Ohio. Information and photo, courtesy The National Screw and Mfg. Co.



KSM Weld Pad

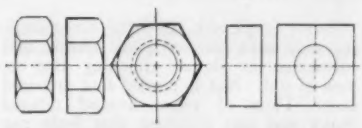
Form: All-metal, internally tapped, cylindrical pin with solid flux tip. Pad is welded to parent material by semiautomatic electric arc-welding process.

Design Features: Provides a permanent tapped hole that can be installed at high speed. Eliminates drilling and tapping.

Materials: Low-carbon steel, and stainless steel.

Sizes: ¼ to 1⅛-in. weld base diameters. Maximum internal thread diameters from No. 8-32 through ⅝-11. Lengths from 3/16 to 36 in.

Source: KSM Products Inc., Moorestown, N. J.



Machine Screw & Stove Bolt Nuts

Form: One-piece, threaded square and hexagon nuts for use with machine screws and stove bolts.

Design Features: General-purpose nuts for moderately loaded assemblies. Hexagon machine screw nut has flat and chamfered top and flat bottom. Square machine screw and stove bolt nut has flat top and bottom.

Materials: Steel, brass, aluminum, and other materials.

Sizes: No. 0 to ⅜-in.; Coarse and Fine threads; Class 2B.

Source: American Standard Square and Hexagon Bolts and Nuts—ASA B18.2-1955.

(See Ad, Page 132)

McLaughlin Expansion Nut

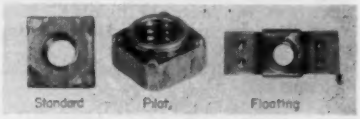
Form: Single-unit, press-in nut assembly consisting of standard square nut mounted tightly in stamped sheet-metal cage with projecting end and retaining tabs. Nut is mounted in square hole with special hand tool which flattens end tabs, causing retaining tabs to lock in hole.

Design Features: Provides securely attached nut that does not have to be held when bolt is tightened. Can be readily adapted to high-production assembly methods. Provides a low-cost prepositioned nut or tapped hole for blind or open locations.

Material: Mild steel.

Sizes: ¼ to ⅜ in.; Coarse or Fine threads.

Source: McLaughlin Co., Birmingham, Mich.



McLaughlin Weld Nuts

Form: Square nut with four projections on bottom face. Nut is attached to panels by resistance or spot welding.

Design Features: Provides a low-cost, prepositioned nut or tapped hole in blind or open locations. Particularly suited for use with thin-gage sheet metal parts where joining would be difficult or impractical by other methods. Projections are designed to give maximum fusion with base material.

Materials: Mild steel.

Sizes: No. 8 to ⅝ in.; Coarse and Fine threads, Class 2B. Body styles include square, rectangular, pilot, caged, and floating designs; spot and projection-welded types.

Source: McLaughlin Co., Birmingham, Mich.

M-F Flange Nuts

Form: One-piece, all-metal, threaded hex nut with enlarged washer base.

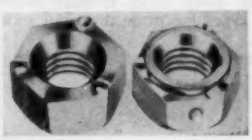
Design Features: Eliminates need for separate washers. May be used to gap oversize holes or where extra bearing surface is required. Can be readily spot-welded to parts.

Materials: Low-carbon steel.

Sizes: No. 6 to ½ in., UNF and UNC threads, Class 2B. Body styles include locking and nonlocking types.

Source: MacLean-Fogg Lock Nut Co., Chicago, Ill.

(See Ad, Page 125)



M-F Weld Nuts

Form: One-piece, all-metal, hex nut with three weld projections and pilot shoulder or recessed seat on bottom face. Nut is projection welded to part surface.

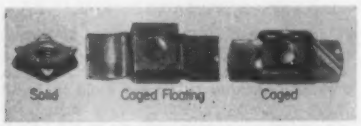
Design Features: Permits assembly of screws or bolts without holding nuts from turning. Pilot design facilitates positioning of nut in holes and provides positive barrier to prevent weld spatter reaching threads. Recessed type can be used in parts with or without holes and has large recess to prevent clogging of threads by weld flow or spatter. Eliminates danger of loose nuts in assembly.

Materials: Low-carbon steel.

Sizes: No. 8 to ½ in.; Coarse and Fine threads, Class 2B. Two pilot lengths: Long for 13 gauge or thicker material; short for 14 gauge or thinner. Body styles include locking and nonlocking types.

Source: MacLean-Fogg Lock Nut Co., Chicago, Ill.

(See Ad, Page 125)



Mount Clemens Weld Nuts

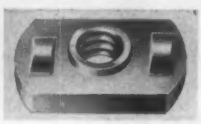
Form: All-metal modified or caged square nut. Nut is projection or spot welded in position.

Design Features: Provides a low-cost prepositioned nut.

Materials: Steel.

Sizes: No. 8 to ¼-in.; Coarse and Fine threads. Body styles include solid, pilot, caged, floating, and double-caged. Nut types include projection and spot-welded designs.

Source: Mount Clemens Metal Products Co., Mount Clemens, Mich.



Ohio RN Weld Nut

Form: Rectangular plate nut with weld projections and pilot collar on bottom face. Pilot collar is mounted in prepared hole and nut projection welded in place.

Design Features: Provides a low-cost, rapidly assembled permanent nut or tapped hole. Pilot collar facilitates assembly and adds extra depth of thread engagement. Can be used on tubular sections, narrow flanges, confined corners, close spacing, and narrow channels in blind or open locations.

Materials: Low-carbon steel.

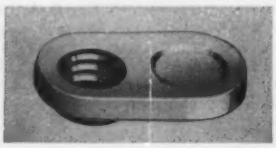
Sizes: No. 6 to ⅜-in.; Coarse and Fine threads. Body styles include several different types for projection and spot welding.

Source: Ohio Nut & Bolt Co., Berea, Ohio.

(See Ad, Page 138)

Ohio Spotweld Nut

Form: One-piece, all-metal nut with thin, flat base and radiused ends. Nut has pilot collar on bottom face and recessed



electrode target area on top face. Pilot collar is mounted in prepared hole and nut spotwelded in place.

Design Features: Provides low-cost, rapidly assembled permanent nut or tapped hole. Pilot collar facilitates assembly and adds extra depth of thread engagement. Recessed target simplifies welding operation and assures proper nut alignment. Can be welded with the same equipment used to join other product components. Adaptable to high-production assembly methods. Particularly suited for use with light-duty spotwelding equipment.

Materials: Low-carbon steel.

Sizes: No. 6 to ⅜ in. Coarse and Fine threads.

Source: The Ohio Nut & Bolt Co., Berea, Ohio.

(See Ad, Page 138)

Pem Self-Clinching Nuts

Form: Single-unit, all-metal, self-clinching nuts with reverse-tapered shanks and corrugated or slotted clinching ring in base of nut. Nut is pressed into prepared hole. Flow of metal around tapered shank and into clinching ring locks nut in place. Two-piece nut design has a retainer with a captive floating nut to accommodate part misalignments.

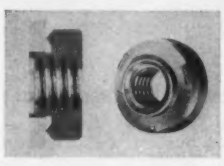
Design Features: Provides rapidly assembled nut anchor for blind or open locations in thin-metal members. Develops high torque and push-out resistance. No special tools required. Tapered shank of nut acts as pilot during installation. Suitable for use with material thicknesses down to 0.030 in. Captive floating nut type permits up to 1/32 in. lateral adjustment in any direction to compensate for slightly off-center holes in mating parts.

Materials: Steel, stainless steel, Monel, aluminum, and aluminum alloy.

Sizes: No 0 to ¾ in.; Coarse and Fine threads. Various grip lengths.

Source: Penn Engineering & Mfg. Corp., Doylestown, Pa.

(See Ad, Page 139)



Pem Weld Nut

Form: All-metal, round body weld nut with three weld projections and extended round shank on bottom surface. Nut is projection welded to part with extended shank serving as pilot in assembly.

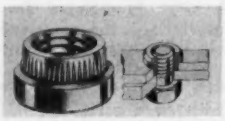
Design Features: Provides load bearing thread anchor for sheetmetal or other parts where tapping is impractical. Round body and extended shank pilot facilitate assembly. Fits into narrow flanges. Extended shank protects threads from weld spatter. Design of projections guards against burnouts in thin sheets. Sheet remains flush on reverse side.

Materials: Mild steel or stainless steel.

Sizes: No. 2 to ¼-in; Coarse and Fine threads.

Source: Penn Engineering & Mfg. Corp., Doylestown, Pa.

(See Ad, Page 139)



Plug Nut

Form: One-piece, all-metal self-clinching nut. Body is in form of hardened round nut in which bottom end is reduced in diameter and tapered. Nut is pressed or driven into prepared hole, seating head. Tapered section locks in hole to hold nut in place.

Design Features: Reusable. Self centering. Provides standard length of thread engagement in thick or thin parts. Provides flat surface on blind side for assembly of mating parts. Can be assembled from one side. Suitable for use with almost any metal. Provides a strong thread anchor in blind or open locations where an ordinary nut cannot be used, where full strength is necessary, or where limited protrusion is required.

Materials: Steel, aluminum, brass, or stainless steel.

Sizes: No. 4 to ¾-in.; all standard tapped threads.

Source: The Lamson & Sessions Co., Cleveland, Ohio.

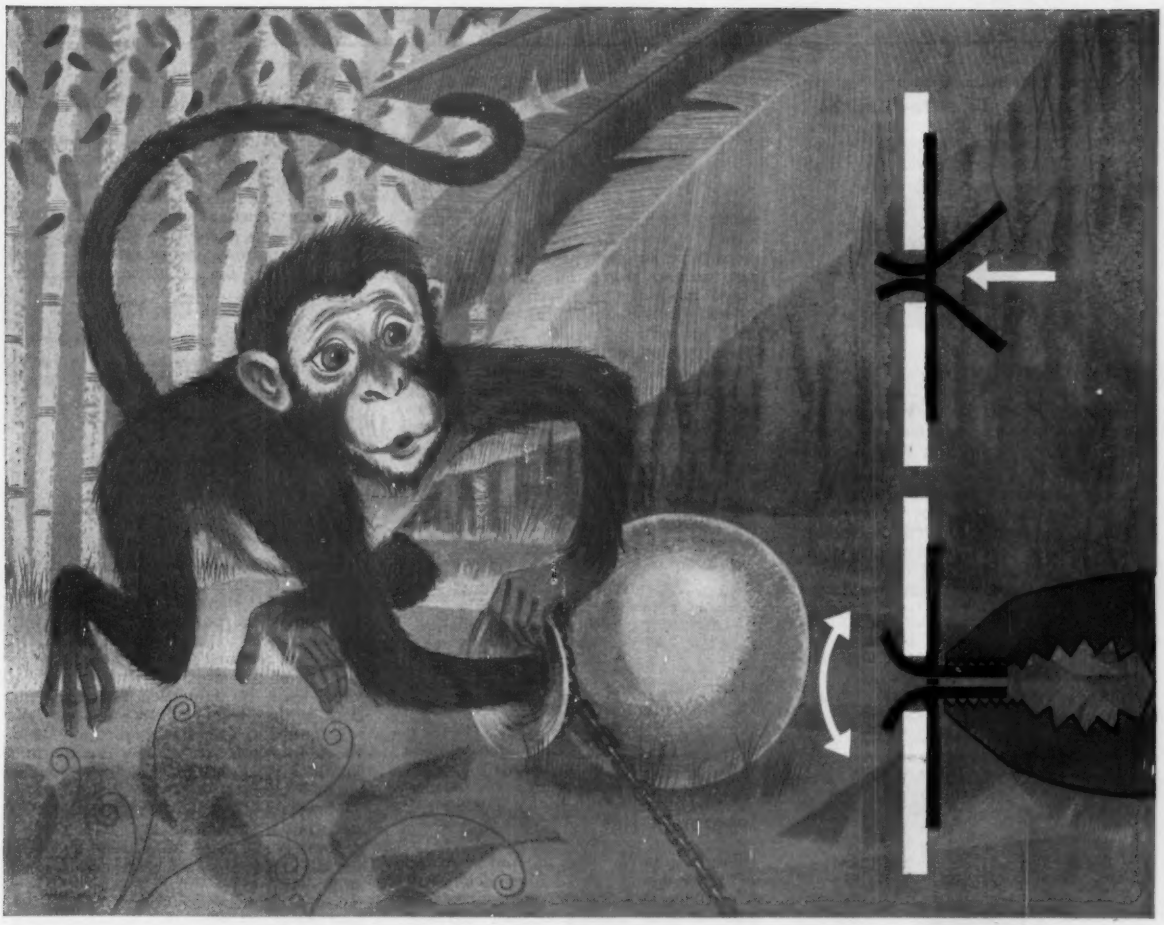
P-Nut

Form: One-piece, all metal, press-in type nut. Bottom external surface of round nut body is reduced in diameter and has retaining groove next to a serrated section. Nut is pressed or driven into a punched or standard drilled hole. Combined effect of serrations and flow of displaced metal into retaining groove lock nut securely in place in hole.

Design Features: Can be installed with standard presses or bench vises or can be driven in place with a hammer. Provides high push-out and torque-out resistance, assuring positive retention under vibration loads and repeated use. Low cost. Locking serrations create a liquid tight seal between nut and prepared hole.

Materials: Case-hardened steel.

Size: 4-40NC to ½-13UNC and ½-20



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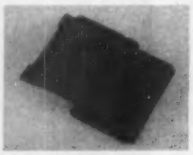
UNF internal threads.

Source: Hi-Shear Rivet Tool Co., Torrance, Calif.



Prestole Nut Clip

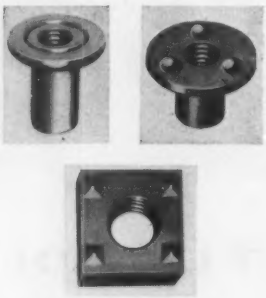
Form: Single-unit clip-on nut assembly consisting of square nut fixed to sheet-metal clip that slips on over edge of panel or thin section.

Design Features: Provides heavy-duty nut member that does not have to be held in place when the bolt is assembled. Tongue of clip acts as lockwasher when assembly is tightened. Used on panels or thin sections where edge fastening is required.

Material: Steel.

Sizes: No. 10 to ⅜ in; Coarse and Fine threads.

Source: Prestole Corp., Toledo, Ohio



Projection-Weld Nuts

Form: One-piece, all-metal, weld nuts with weld projections on one surface. Nut is projection welded to part surface.

Design Features: Provides a low-cost, permanent nut attachment for steel stampings or other parts where threaded hole is impractical. Adaptable to high-speed assembly methods. Particularly suited for use in blind or inaccessible locations. Flanged types with weld projections under head are mounted in prepared hole and are used to provide self-locating through nut with extra-long thread engagement. Other types can be used without a hole where a flush surface is required for appearance. Type with 360-deg ring projection are used where hermetic seal is required.

Materials: Low-carbon steel.

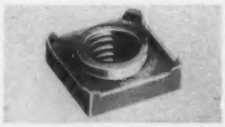
Sizes: No. 6 to ⅜ in., Coarse and Fine threads.

Source: Information and photo, courtesy The Ohio Nut & Bolt Co., Berea, Ohio.

(See Ad, Page 138)

Quintlock Nut

Form: One-piece, all-metal self-clinching nut. Nut has square head and round



shank of reduced diameter with reverse surface taper. When nut is pressed into prepared hole and head seated against part surface, prongs on corners of head imbed in surface to prevent turning, and tapered shank locks against hole wall to resist pull out.

Design Features: Provides flush-mounted tapped hole in soft sheet metal parts. Can be assembled with hammer, using special backing tool. Suitable for material thickness of 0.038-in. and over. Used to provide a strong threaded hole in aluminum, copper, or soft metal plates for bolting attachments.

Materials: Steel.

Sizes: No. 4-40 to ¼-20; machine screw threads.

Source: Fox Products Co., Philadelphia, Pa.

Separation Nut

Form: Instantly releasing nut assembly for separation systems. After detonation of small explosive squib, retainer cap tabs shear-off first, causing retainer cap and case containing squib and connector to start withdrawal from bolt. Cam action exerted by keys causes nut segments to pivot and separate from bolt threads.

Design Features: Controlled separation is a mechanical function activated by a small explosive charge. Captive configuration contains all component parts after detonation, eliminating fragmentation. Capable of carrying full torque, tension, and shear loads of an internal wrenching bolt heat treated to 160,000 to 180,000 psi ultimate tensile strength.

Materials: Heat-treated alloy steel.

Sizes: ¼-28 to ¾-16; UNF high-strength bolt threads. Nut styles include captive and noncaptive types.

Source: Hi-Shear Rivet Tool Co., Torrance, Calif.

Slotted Nuts

Form: Regular hexagon nut with slots milled across the flats on one face. Cotter pin or safety wire inserted in drilled hole in bolt can be used to lock nut in place.

Design Features: General-purpose nut that can be readily adapted to provide locking features. Finished series is designed for average use. Heavy series is thicker and wider and is suitable for use with heavy loads and large bolt clearances.

Materials: Steel, brass, aluminum, and other standard materials.

Sizes: ¼ to 4-in.; Coarse, Fine, and 8-thread series; Class 2B. Body styles include regular semifinished, heavy semifinished, and finished thick.

Source: *American Standard Square and Hexagon Bolts and Nuts*—ASA B18.2-1955. Photo, courtesy Anti-Corrosive Metal Products Co. Inc., Castleton-on-Hudson, N. Y.

See Ad, Page 132)

Speed Grip

Form: Two-piece, preassembled snap-in nut unit consists of standard square nut mounted in stamped, sheet-metal cage with projecting prongs. Prongs snap into prepared hole to hold nut in place.

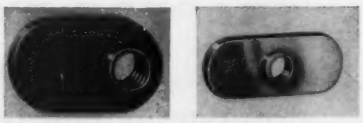
Design Features: Provides securely attached nut that does not have to be held when bolt is tightened. However, nut floats within cage to offset mounting hole misalignment. Can be installed by hand. Provides secure retainer for square nuts in blind locations on sheet metal panels or thin sections.

Materials: Cage is heat-treated spring steel; nut is steel.

Sizes: No. 6 to ½-in.; Coarse and Fine threads. Body styles include J and U type retainers.

Source: Tinnerman Products Inc., Cleveland, Ohio.

(See Ad, Page 117)



Spotweld Nuts

Form: One-piece, all-metal nut with thin, flat base and pilot collar on bottom face. Pilot collar is mounted in prepared hole and nut spotwelded in place.

Design Features: Provides a low-cost, rapidly assembled permanent nut or tapped hole. Pilot collar facilitates assembly and adds extra depth of thread engagement. Can be welded with the same equipment and settings used for other assembly components. Adaptable to high-production assembly methods.

Materials: Low carbon steel.

Sizes: No. 6 to ⅜ in., Coarse and Fine threads. Body styles include offset and center threaded designs.

Source: Information and photos, courtesy The Ohio Nut & Bolt Co., Berea, Ohio.

(See Ad, Page 138)

Square Nuts

Form: One-piece, all-metal, standard threaded square-body nut.

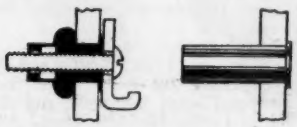
Design Features: General-purpose nut. Not finished on any surface. Top of nut

is flat and chamfered or washer crowned.

Materials: Steel, brass, aluminum, and other standard materials.

Sizes: ¼ to 1½ in.; Coarse threads; Class 2B. Body styles include regular and heavy.

Source: *American Standard Square and Hexagon Bolts and Nuts*—ASA B18.2-1955. Photo, courtesy Anti-Corrosive Metal Products Co. Inc., Castleton-on-Hudson, N. Y.
(See Ads, Pages 123, 132, 133, 140, 141)



Well-Nut

Form: Single-unit, blind anchor nut consisting of rubber sleeve with flange at one end and brass nut bonded in other end. Sleeve is pressed into drilled hole with flange against part surface and screw is inserted to engage nut. Tightening of screw causes rubber sleeve to draw in tightly against back of part and form blind head.

Design Features: Provides a resilient thread anchor for blind or open locations in thin plastics, porcelain, glass, and other materials difficult to fasten. As sleeve is drawn tight, rubber is forced into threads of the screw, preventing air or water leakage and loosening by vibration. Lightweight. Reduces sound transmission and prevents squeaks. Can be expanded against side of cavity.

Materials: Sleeve is natural or neoprene rubber composition; nut is brass.

Sizes: No. 6-32 to ⅜-16. Body diameters from ¼ to ¾-in. Lengths from ⅜ to 1-in.

Source: Rockwell Products Corp., Newark, N. J.

Wing and Thumb Nuts

Form: One-piece, all-metal, round threaded nuts with wing lugs or with wide head that is knurled or scalloped on the edge for ease of manual assembly.

Design Features: Provide a large finger gripping surface for manual assembly. Particularly suited to applications where frequent removal and replacement or adjustment of nuts are required. Provide a neat appearance.

Materials: Steel, brass, aluminum, zinc, and other materials.

Sizes: No. 4 to ¾-in.; Coarse and Fine threads.

Source: Produced by several manufacturers. Photos, courtesy Gries Reproducer Corp., New Rochelle, N. Y.
(See Ad, Page 131, 133)

Locknuts

Anco Self-Locking Nut

Form: Single-unit, all-metal prevailing-torque locknut. End of locking pin mounted to nut travels between threads of bolt to provide ratchet-like locking action.

Design Features: Reusable. Provides continuous positive locking action when locking pin is engaged. Assembled and removed with wrench. Cost is comparable to conventional nut and lock washer. Provides securely seated locknut or stop nut where effect of vibration is a problem.

Materials: Nut is open-hearth carbon steel with rust resistant locking pin. Also available in bronze, brass, aluminum, and stainless steel.

Sizes: ¼ to 3-in.; Coarse and Fine threads; Class 2B. Body styles include heavy, regular, and finished hex.

Source: Automatic Nut Co. Inc., Lebanon, Pa.

An-Cor-Lox Locknut

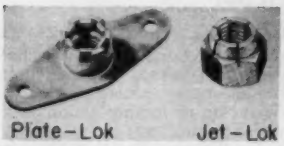
Form: Single-unit, all-metal, free-spinning locknut. Metal insert in base of nut is crushed when seated to develop wedge-locking action.

Design Features: Reusable. Wedge-locking action resists severe vibration and stress conditions, relatively high temperatures, and repeated immersion and drying. Can be assembled with standard wrenches. Bolt does not have to protrude through nut for full locking efficiency. Crushed insert compensates for misalignment of bolt or nut, and forms liquid and gas-tight seal.

Materials: Nut body is carbon steel; insert is bronze.

Sizes: ¼ to 1½-in.; NC, NF, UNC, and UNF threads; Class 2 and 3. Body styles include hex and others.

Source: An-Cor-Lox Div., Schnitzer Alloy Products Co., Elizabeth, N. J.



Boots Radial Locking Nuts

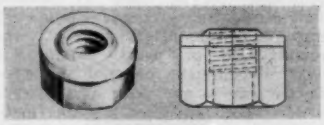
Form: One-piece, all-metal, prevailing-torque locknut. Upper section of nut has flared petals, curving in and down. Spring tension of petals develops powerful radial locking grip on bolt threads.

Design Features: Reusable. Provides continuous locking grip when petal section is engaged. Locking action resists severe vibration conditions.

Materials: Steel and corrosion-resistant steel.

Sizes: No. 10 to ⅜-in.; NF-3B threads. Body styles include full and thin hex, anchor, and channel base.

Source: Boots Aircraft Nut Corp., Norwalk, Conn.



Brilok Stop Nut

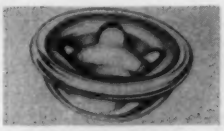
Form: One-piece all-nylon prevailing-torque locknut. Bore of nut is only partially tapped. As screw enters unthreaded portion of bore, thread-forming action of screw thread develops a strong friction lock.

Design Features: Reusable. Provides a durable, lightweight nut that resists vibration and is noncorrosive and electrically nonconductive. Resilient nylon construction permits nut to be reused even after stripping; threads reform when nut is removed and replaced. Can be assembled with standard tools.

Materials: Zytel 101.

Sizes: No. 4 to ¼-in.; Coarse and Fine threads. Body style is hex with washer face.

Source: Byrd Plastics Inc., Erie, Penna.



Capped Ratchet Plate

Form: Single-unit, all-metal cap locknut consisting of cap and ratchet plate. Nut is pushed or hammered on end of roll or axle. Teeth on ratchet plate bite into rod surface to lock nut in position.

Design Features: Provides low-cost locking fastener for assembly of lightly loaded parts on rods or axles. Lends itself to knock-down assembly.

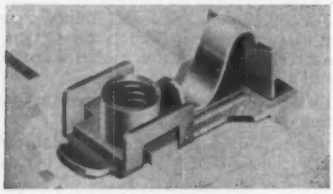
Materials: Cap is steel or aluminum; ratchet plate is 1050 steel.

Sizes: ⅛ to ½ in. rod diameters. Cap types include designs for push-on or hammered assembly, light or heavy locking action.

Source: Carr Fastener Co., Div. of United-Carr Fastener Corp., Cambridge, Mass.

Clip Nut

Form: Single-unit, clip-on, prevailing torque locknut assembly consisting of nut fixed to sheet-metal clip. One hole is provided in the receiving panel and the clip nut is pushed over the edge of the panel until it snaps into place.

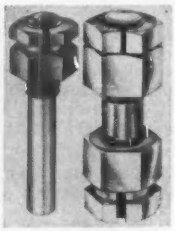


Design Features: Nut provides thread lock conforming to MIL-N-25027. Develops full bolt tensile values. Panel interior mountings can be made by providing small access hole. Torque loads are resisted by portion of spring which wraps around edge of panel. Automatically adapts to different material thicknesses. May be used in any plate-nut application where slight separation of the mating panels (about 0.018 in.) is not considered objectionable.

Material: Steel.

Sizes: No. 6-32, No. 8-32 and No. 10-32. Panel thicknesses from 0.020 to 0.150 in. and edge margins from 0.25 to 0.65 in.

Source: Shur-Lok Corp., Anaheim, Calif.



Columbia Locknut

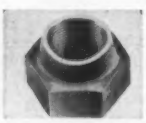
Form: Two-piece, all-metal, free-spinning locknut consisting of upper split-nut element with tapered neck that fits into mating tapered seat in lower main nut section. When upper element is tightened into tapered seat, it is radially compressed to develop locking grip on bolt threads.

Design Features: Reusable. Provides positive locking grip that resists severe vibration. Both members are free spinning until locked. Can be assembled as seated locknut with one wrench or as stop nut with two.

Materials: Steel.

Size: ¼ to 2 in.; Coarse and Fine threads. Body style is hex.

Source: Columbia Nut & Bolt Co. Inc., Bridgeport, Conn.



Conelok

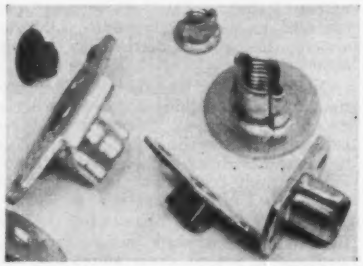
Form: One-piece, all-metal, prevailing-torque locknut. Three sectors of upper tapered cone portion are preformed inwardly. When nut is applied, sectors are elastically returned to circular form, developing strong locking grip on bolt.

Design Features: Reusable. Shape of cone sector displacement insures conformity with mating bolt and maximum friction contact area. Has high fatigue life. Resists thread injury to mating bolt from galling, material pickup, and burrs. Provides continuing locking action when cone section is fully engaged.

Materials: Carbon steel, corrosion-resistant steel, brass, and aluminum.

Sizes: No. 10 to 1½ in., Coarse and Fine threads. Body styles include finished thin and heavy hex.

Source: National Machine Products Co., Utica, Mich.



Con-Torq Nut

Form: One-piece, all-metal, prevailing torque locknut. Body of nut is in form of a threaded barrel with two longitudinal crimped ribs and a flanged base. Barrel is slightly tapered inward at top and spreads apart when engaged with screw thread to provide secure spring-locking action.

Design Features: Reusable. Provides a lightweight, secure seated locknut, adjusting nut, or stop nut. Locking action withstands vibration or changing atmospheric conditions. Adaptable to high-speed assembly operations. Can be assembled with pliers or hex wrench.

Materials: Spring steel.

Sizes: No. 2 to ⅜-in.; Coarse and Fine threads. Body styles include several flange designs.

Source: Con-Torq Inc., Subsidiary of North & Judd Mfg. Co., New Britain, Conn.

Crest Nut

Form: One-piece, all-metal, free-spinning locknut. Compression of arched base coupled with inward gripping motion of arched, slotted, thread-engaging section produces secure locking action as nut is tightened against seat.

Design Features: Reusable. Light weight. Resists vibration. Provides low-cost seated locknut for light assemblies.

Materials: Heat-treated spring steel.

Sizes: No. 8 to 7/16 in.; NPS threads; Class 3. Body style is hex-washer, regular-acorn and wing type.

Source: Crest Products Inc., Union, N. J.

Decker Lock Nuts

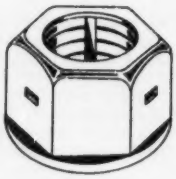
Form: One-piece, all-metal prevailing torque-locknut. Top two threads of nut are reduced by pressure-forming to develop interference locking grip on bolt.

Design Features: Reusable. Provides a low-cost, reliable, seated locknut or stop nut. Locking action is continuous when top two threads are enlarged. Resists vibration.

Material: Steel.

Sizes: ¼ to 1 in., UNC and UNF threads, Class 2B. Body styles include finished and heavy hex, weld, and clinch.

Source: Decker Nut Mfg. Corp., Albion, Mich.



Delron No. 5 Locknut

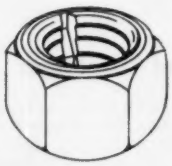
Form: Single-unit, all-metal, free-spinning locknut assembly consisting of split, hexagonal threaded core mounted in shell welded to base plate. When base plate is seated, further tightening develops locking action.

Design Features: Reusable. Free spinning until seated. Develops prevailing-torque action when locked. After backing off nut, locking action can be released manually to permit free-spinning removal. Resists extreme vibration. Provides self-locking nut with integral washer.

Materials: Corrosion-resistant steel.

Sizes: No. 10 to 7/16-in.; UNF threads. Body style is hex.

Source: The Delron Co. Inc., South Gate, Calif.



Dura-Loc 1600 Locknut

Form: Single-unit, all-metal, free-spinning locknut consisting of split, tapered, threaded core keyed into metal shell with mating tapered bore. When shell is seated, further rotation of nut forces core downward to produce collet-type locking action.

Design Features: Reusable. Maximum application temperature is 1600 F. Locking action is equally effective on high or low tolerance bolt threads. Provides vibration-resistant seated locknut under high

your product's reputation and sales... can go down hill fast

... *if nuts keep coming loose*

Suppose you were your own customer, and bought the product *you* make. You'd expect it to stand up to the job, whether it was a racing cart, a heavy-duty crawler, or a crusher. You'd want it to endure the bumps and thumps and constant vibration of rugged use without coming unstuck at the bolts. If a nut came loose and made you lose time or production, you'd certainly think twice about buying that product again.

This is precisely why so many of America's leading manufacturers have guaranteed the reliability of critical bolted connections on their products with Elastic Stop® nuts.

They know that a product's reputation for dependability is built in the field and they know that reorders are written in customers' maintenance records. They've verified through field experience that in the long run Elastic Stop nuts pay their own way because the exclusive nylon locking inserts keep them from working loose . . . even under the most punishing conditions of shock, impact or vibration! Elastic Stop nuts are the equivalent of "free" insurance against fastener failure for *their* product!

Whether your product sells for three dollars or for thousands, we think you'll be interested in a copy of the hex nut catalog No. 706. It details the regular, thin, heavy and light hex types in USS and SAE thread series and various materials and finishes; plus many dimensional "specials".

ESNA's complete line may change many of *your* "special" requirements into standard parts. Write Dept. S-52-94, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.

ESNA®

for the ring **O** *of reliability*

ELASTIC STOP NUT CORPORATION OF AMERICA

temperature conditions.

Materials: Stabilized corrosion-resistant steels.

Sizes: No. 6 to 7/16-in.; UNC and UNF threads. Body style is hex.

Source: The Delron Co. Inc., South Gate, Calif.

Esna Beam-Type Locknut

Form: One-piece, all-metal, prevailing-torque locknut. Upper threaded conical crown is slotted to form six radial beams which are deflected inward. Beam sections grip screw thread firmly to provide tight friction lock.

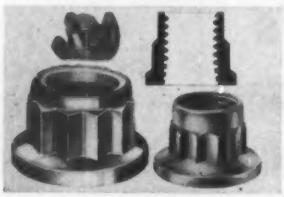
Design Features: Reusable. Designed for use at temperatures from 250 to 1200 F. Provides constant locking action at any position on bolt when beam sections are fully engaged. Relief provided by slots assures that locking grip is evenly applied, without destructive galling of bolt threads or plating.

Materials: Steel, copper-base alloy, and stainless steel.

Sizes: No. 4 to ¾-in.; NF and NC threads, Class 3. Body styles include hex, double hex, anchor, weld and rivet types, and others.

Source: Elastic Stop Nut Corp. of America, Union, N. J.

(See Ad, Page 121)



Esna Double/Durability Nut

Form: Single-unit, prevailing-torque locknut with modified UNF, Class 3 thread form to equalize distribution of applied load on bolt threads. In this modified thread form, the pitch diameter is the same as for a standard thread but the base of the lower thread is decreased and a special small angle bottom countersink is used. The nut is assembled on standard threaded parts. Prevailing-torque locking action is provided by either a nylon locking collar (under 250 F) or all-metal locking device (over 250 F).

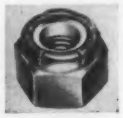
Design Features: Interchangeable in use with standard nuts. Modified thread form reduces high load concentration on first engaged threads and distributes loads evenly along bolt threads to develop maximum fatigue properties. Provides high reliability under fatigue loading. Particularly suited for critical applications where frequent retightening or replacement are standard maintenance procedure.

Materials: Alloy steel.

Sizes: ¼-28 to 1½-12 UNF-3B (modified) threads. Body styles include hex, double hex, and barrel.

Source: Elastic Stop Nut Corp. of America, Union, N. J.

(See Ad, Page 121)



Esna Insert Type Locknut

Form: Single-unit, prevailing-torque locknut consisting of metal nut body with nylon compression collar built into top of nut. Plastic collar distorts when threaded on screw to provide friction locking action.

Design Features: Reusable interchangeably within tolerance limits of Class 3 screws; elastic collar compensates tolerance variations. Provides constant uniform locking grip at any position on bolt when collar is in full engagement. Maintains secure lock under severe operating conditions. Collar serves as liquid seal, preventing thread corrosion and assuring easy removal of nut. Maximum application temperature is 250 F.

Materials: Nut body is steel, aluminum, brass, and corrosion resistant steel; collar is red nylon.

Sizes: No. 0-80 to 2-4½; NC, NF, and 8 thread series. Body styles include hex, clinch, anchor, spline, barrel, weld, and many others.

Source: Elastic Stop Nut Corp. of America, Union, N. J.

(See Ad, Page 121)

Esna Lightweight Locknut

Form: One-piece, all-metal, prevailing-torque locknut. Upper part of threaded cylinder is elliptically offset to provide a controlled degree of deflection in the threads. Deflected threads grip bolt to develop strong locking torque.

Design Features: Reusable. Provides constant locking action at any position on bolt when elliptical thread section is fully engaged. Designed to minimize size and weight. Locking action remains effective under elevated temperature conditions.

Materials: Carbon steel and stainless steel.

Sizes: No. 0 to ½ in.; Coarse and Fine threads, Class 3B. Body styles include miniature, internal-external wrenching, hex, 12-point, clinch, self-aligning, barrel, fixed and floating anchor, and channel types.

Source: Elastic Stop Nut Corp. of America, Union, N. J.

(See Ad, Page 121)

Expansion Nut

Form: One-piece, all-metal, prevailing-torque locknut made as stamping. Nut is snapped into square hole in panel or thin section by hand. Spring arms are spread apart by screw thread, wedging nut in position and providing a secure locking action.

Design Features: Reusable. Resists loosening from vibration. Best suited for front mounting applications. Can be assembled in blind locations. Locking action compensates for thread tolerance variations. Provides low-cost locking fastener in light assemblies.

Materials: Heat-treated spring steel.

Sizes: No. 6 to No. 10; sheet-metal screw threads.

Source: Tinnerman Products Inc., Cleveland, Ohio.

(See Ad, Page 117)

Fastite Nut

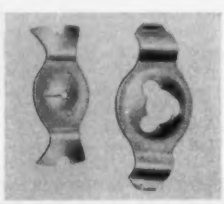
Form: Single-unit, all-metal, free-spinning locknut consisting of pre-assembled standard nut and helical spring washer.

Design Features: Reusable. Washer is permanently attached to nut, yet is free to rotate during tightening. Eliminates separate handling of nut and washer in assembly. Provides a low-cost, rapidly assembled locknut.

Materials: Carbon steel.

Sizes: ¼ to ⅜ in., NC and NF threads. Nut body style is finished hex.

Source: Reliance Div., Eaton Mfg. Co., Massillon, Ohio.



Fishtail Fasteners

Form: One-piece, all-metal, spring-action locknut for unthreaded studs. Nut is pressed onto unthreaded stud and teeth around circular opening bite into surface to produce firm locking grip.

Design Features: Reusable. Adaptable to high-speed assembly. Resists vibration. Locking grip is independent of the pressure of spring take-up legs. Can be used on flat or contour surfaces.

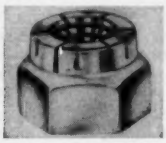
Material: Steel.

Sizes: 1/16 to ½-in. stud diameters.

Source: Carr Fastener Co., Div. of United-Carr Fastener Corp., Cambridge, Mass.

Flexloc Locknut

Form: One-piece, all-metal, prevailing-torque locknut. Formed locking segment



of nut is shaped like collar and slotted to form six threaded segments which are deflected inward. Slotted sections "pressure grip" screw thread to provide locking action.

Design Features: Reusable. Spins on freely on screw thread until locking collar is engaged, then wrench is used. Provides constant locking torque at any position on screw when collar is fully engaged. Will resist loosening effects of severe vibration.

Materials: Steel, corrosion-resistant steel, brass, and aluminum.

Sizes: No. 0 to 2 in.; NC, NF and 8-thread series; Class 2B and 3B. Body styles include microsize, regular and thin hex, aircraft hex, and 12 point, clinch, and others.

Source: Standard Pressed Steel Co., Jenkintown, Pa.

Flite-Lok

Form: One-piece, all-metal, prevailing-torque locknut. Upper threads are deformed into elliptical shape to develop locking grip on bolt.

Design Features: Reusable. Provides lightweight locknut with high strength-weight ratio. May be wrenched internally as well as externally, reducing wrenching clearance requirements and permitting miniaturization of components. Maximum application temperature is 900 F.

Materials: High-carbon steel and A-286 superalloy.

Sizes: No. 4-40 to 5/16-24.

Source: Boots Aircraft Nut Corp., Norwalk, Conn.

GRC Locking Wing Nut

Form: One-piece, all-metal free-spinning wing locknut. Serrations in bottom surface of nut grip part surface when nut is seated to provide locking action.

Design Features: Reusable. Can be rapidly assembled by hand. Eliminates separate handling of nut and lockwasher.

Materials: Die-cast zinc alloy.

Sizes: No. 4 to 5/16-in.; Coarse and Fine threads.

Source: Gries Reproducer Corp., New Rochelle, N. Y.

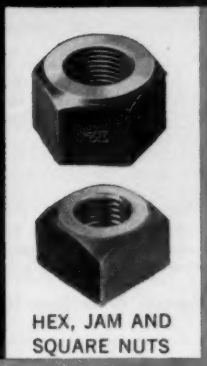
Greer Stop Nut

Form: Single unit, prevailing-torque

Here is Your Guide to

LARGE FASTENERS

HEX, SQUARE AND SOCKET HEAD BOLTS



HEX, JAM AND SQUARE NUTS

THREADED AND LOOP RODS

RECESSED PIN NUTS AND PINS

HEX AND SOCKET HEAD CAP NUTS

COUPLING AND SLEEVE NUTS

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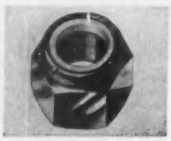
Size: 1 3/4" thru 12" bolt diameter

DYSON

Circle F-10 on Page 97



locknut consisting of metal nut body with elastic fiber or plastic insert built into top of nut. Resilient insert is compressed by bolt threads and produces constant friction grip.

Design Features: Reusable. Provides continuous locking action when collar is fully engaged. Collar seals against fluid leakage. Maintains secure lock uder severe operating conditions.

Materials: Nut body is steel, stainless steel, brass, or aluminum; insert is green fiber or nylon.

Sizes: No. 0 to 1¼ in.; NC and NF threads, Class 2B and 3B. Body styles include full and thin hex, high tensile hex, miniature, clinch, spline, instrument and cap.

Source: Greer Stop Nut Co., Chicago.

Gripco Centerlock Nut

Form: One-piece, all-metal, prevailing-torque locknut. Threads at center of nut are displaced at three or six points to develop strong friction grip on bolt.

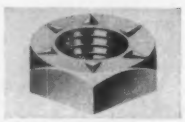
Design Features: Reusable. Provides a low-cost, seated locknut or stop nut that can be applied from either end. Locking action is continuous when center thread section is engaged. Adaptable to high-speed assembly methods. Permits flush application on end of bolt. Resists vibration.

Materials: Steel and brass.

Sizes: No. 6 to 1½ in., UNC and UNF threads, Class 2B. Body styles include machine screw, finished and heavy hex and hex jam, high hex, double chamfered, and open and closed-end cap.

Source: Grip Nut Co., South Whitley, Ind.

(See Ad, Page 127)



Gripco Locknut

Form: One-piece, all-metal, prevailing-torque locknut. Triangular depressions in upper surface of nut deflect top thread to provide controlled friction locking action.

Design Features: Reusable. Provides positive continuous vibration-resistant holding action in any position on bolt when deflected thread is engaged. Nut dimensions identical to standard semifinished nut. Nuts are single chamfer, washer faced.

Materials: Steel, brass, stainless steel.

Sizes: No. 6 to 1½-in.; UNC and UNF threads; Class 2B. Body styles include regular jam, and high hex, weld, clinch, and flange.

Source: Grip Nut Co. South Whitley, Ind.

(See Ad, Page 127)

Hi-Stress

Form: One-piece, all-metal, prevailing-torque locknut. Body of nut is in form of threaded split sleeve with flange base. Split sleeve is tapped slightly smaller than bolt thread to produce locking fit.

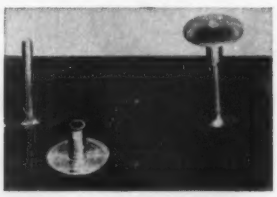
Design Features: Reusable. Provides constant locking torque at any position on bolt. Provides low cost seated locknut or stop nut.

Materials: Heat-treated spring steel.

Sizes: No. 4 to 5/16-in.; Coarse and Fine threads.

Source: Tinnerman Products Inc., Cleveland, Ohio.

(See Ad, Page 117)



Huck Threadless Stud Cap

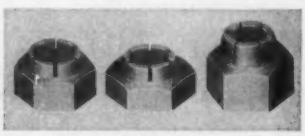
Form: Single-piece cap used with grooved or threaded weld stud. Consists of sleeve-type shank with large diameter head and is installed by tapping it onto the end-welded stud with a hammer.

Design Features: Designed specifically for installing insulation, but provides low-cost, high-speed fastening method wherever use of a fastener of moderate strength is satisfactory. Features positive interference lock and high resistance to removal forces.

Materials: Aluminum.

Sizes: ⅛ and 3/16-in. nominal diameters. Various shank lengths. Cap head style is truss (1-in. diameter for both sizes).

Source: Huck Mfg. Co., Detroit, Mich.



Huglock

Form: One-piece, all-metal, prevailing-torque locknut. Upper threaded portion of nut is tapered and slotted to form six segments which are curved inward. Segments press in and down on screw threads to produce secure friction locking action.

Design Features: Reusable. Nut starts freely on screw thread and is easily assembled with standard hand or speed wrenches. Provides constant locking action at any position on bolt when slotted section is engaged. All-metal design provides maximum shear strength. Resists severe shock and vibration conditions.

Materials: Carbon steel, corrosion-resistant steel, brass, and aluminum.

Sizes: No. 10 to 1½ in.; UNC and UNF threads, Class 2B. Body styles include thin, regular, and thick hex as well as others.

Source: National Machine Products Co., Utica, Mich.

(See Ad, Page 140)

Jacobson Combination Nut-Washer

Form: Single unit, all-metal, free-spinning locknut consisting of a preassembled nut body and Belleville washer. Belleville washer provides spring locking action when nut is seated and tightened.

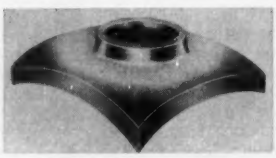
Design Features: Reusable. Provides a low-cost, rapidly assembled locknut. Eliminates separate handling of washer and nut.

Materials: Steel, brass, aluminum, or stainless steel.

Sizes: All standard machine screw threads; Class 2B. Nut style is hex.

Source: Jacobson Nut Mfg. Corp., Kenilworth, N. J.

(See Ad, Page 141)



Jacobson Spring Nut

Form: One-piece, all-metal, free-spinning locknut. When nut is seated and tightened, compression of arched base of nut applies tension to mating threads to produce locking action.

Design Features: Reusable. Turned down corners of nut grip seating surface to hold nut in position while screw is being tightened. Provides low-cost, vibration-resistant locknut.

Materials: Steel, brass, aluminum, or stainless steel.

Sizes: All standard machine screw threads; Class 2B.

Source: Jacobson Nut Mfg. Corp., Kenilworth, N. J.

(See Ad, Page 141)

Jacobson Stop Nut

Form: Single-unit, prevailing-torque locknut consisting of metal nut body with elastic fiber insert built into top of nut. Insert is compressed by bolt threads and produces constant friction grip.

Design Features: Reusable. Provides con-

tinuous locking action when collar is fully engaged. Collar seals against fluid leakage. Can be used as stop nut or seated locknut.

Materials: Nut body is steel, brass, aluminum, or stainless steel; insert is fiber.

Sizes: All standard machine screw threads; Class 2B. Nut style is hex.

Source: Jacobson Nut Mfg. Corp., Kenilworth, N. J.

(See Ad, Page 141)

J-Lok

Form: Single-unit, prevailing-torque locknut consisting of metal nut body with elastic plastic ring built into center section of nut. Plastic ring distorts when threaded on screw to provide firm friction-locking grip.

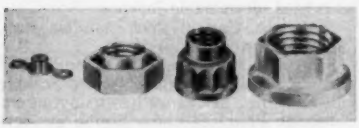
Design Features: Reusable. Provide continuing locking grip when center section is engaged. Resists vibration. Can be used as stop nut or seated locknut. Reversible; starts freely when threaded on bolt from either end.

Materials: Nut body is steel, aluminum, brass, or stainless steel; locking ring is Delrin.

Sizes: All standard machine screw threads; Class 2B. Nut style is hex.

Source: Jacobson Nut Mfg. Corp., Kenilworth, N. J.

(See Ad, Page 141)



Kaylock Locknuts

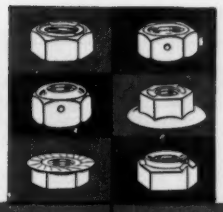
Form: One-piece, all-metal, prevailing-torque locknuts. Upper threads are deformed into elliptical shape to develop locking action.

Design Features: Reusable. Provides lightweight locknut with high strength-weight ratio. Locking action is continuous when elliptical threads are engaged.

Materials: Heat-treated carbon steel, corrosion-resistant steel, and heat-treated alloy steel.

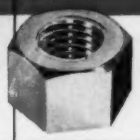
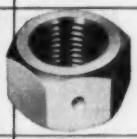
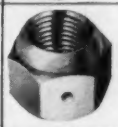
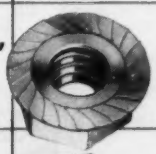
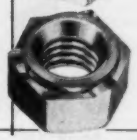
Sizes: No. 2 to ¾ in.; UNC and UNF threads, Class 3B. Body styles include stamped hex, six point self-aligning, six point reduced height with captive washer, twelve point high tensile, twelve point high tensile with reduced wrench, and others.

Source: Kaynar Mfg. Co. Inc., Los Angeles, Calif.

One  of these

CAN IMPROVE YOUR PRODUCT...

SIX GREAT
MACLEAN-FOGG
LOCK NUTS

MF **UNI-TORQUE**		A free starter with lock at the top. Withstands severe vibrations. Cuts assembly time.
MF **TWO-WAY**		The Lock's in the center of nut. Can be applied from either end. Permits bolt end to be flush with, or below, top of nut.
MF OPEN END **CAP NUT**		Has two-way center-of-nut lock. Used on furniture, appliances, toys, lawn mowers, tools, etc.
MF UNI-TORQUE **FLANGE NUT**		Combination lock nut and washer. Use on oversized holes; where extra bearing surface is needed.
MF **"WHIZ-LOCK"** FLANGE NUT		This one spins on. Serrations take a firm grip on work. Break loose torque higher than seated torque.
MF PILOT TYPE **WELD NUT**		You can have it with or without lock. Simplifies assemblies by means of self-locating pilot.

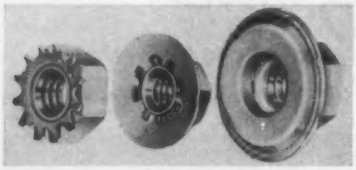
CIRCLE NUMBER FOR ILLUSTRATED CATALOG

SEE OUR CATALOG IN SWEET'S

MACLEAN-FOGG MF LOCK NUTS

MacLean-Fogg Lock Nut Company
5535 N. WOLCOTT AVENUE
CHICAGO 40, ILLINOIS

1925 35 1960 ANNIVERSARY



Keps

Form: Single-unit, all-metal, free-spinning locknut consisting of preassembled standard nut and toothed lockwasher.

Design Features: Reusable. Eliminates need for separate assembly of washer and nut. Lockwasher is free to turn. Provides low-cost, rapidly assembled locknut. Can be readily adapted to self-sealing lockwasher designs.

Materials: Mild steel.

Sizes: No. 5 to ⅜-in.; Coarse and Fine threads. Body styles are finished hex and machine screw types. Washer styles include external, dished, and domed lockwashers as well as plain, dished, conical, and sealing washers.

Source: Shakeproof Div., Illinois Tool Works, Elgin, Ill.

Klincher Locknut

Form: Single unit, all-metal, free-spinning locknut. Grooved washer at bottom of nut is pressed over threaded section suspended from main nut body. When seated under proper torque, washer compresses causing inner threaded section to move in and lock radially and axially on bolt.

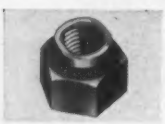
Design Features: Reusable. Spins down freely until washer is seated. Bulk of load moves up into main body of nut when locking threads elongate under their load. Reduces high stress concentration and torsional load normally found in first three threads in nut and bolt, permitting added wrench torque to be applied before elastic limit of nut is exceeded. Maximum application temperature is 1600 F. Provides vibration-resistant bolted connection that holds solid and resists thread wear.

Materials: Types 303, 304, 347, and A-286 stainless steel, alumel, and Chromel P.

Sizes: No. 2 to 1 in.; Coarse and Fine threads. Body styles include standard and thin hex.

Source: Klincher Locknut Corp., Indianapolis, Ind.

(See Ad, Page 141)



Lamson Locknut

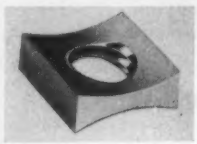
Form: One-piece, all-metal, prevailing-torque locknut. Heat-treated, threaded crown collar at top of standard nut body is slightly distorted from round and produces vise-like locking grip on bolt threads.

Design Features: Reusable. Spins freely on bolt until threads of locking collar are engaged, then wrench is used. Locks in any position on bolt when collar is engaged. When working threads in main body of nut assume load, grip threads in collar are free to exert full locking pressure. Eliminates pitch interference since thread has same lead throughout. Withstands temperatures to 800 F and severe vibration.

Materials: High-carbon heat-treated steel.

Sizes: No. 10 to 2-in.; all standard threads; Class 3.

Source: The Lamson & Sessions Co., Cleveland, Ohio.



M-F Locknut No. 1

Form: One-piece, all-metal, free-spinning locknut that starts from either side. Arched surface of nut flattens when tightened against the top of a conventional nut, causing threads to deflect from true helix, firmly gripping bolt threads.

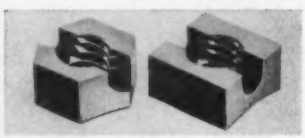
Design Features: Spins freely until seated. Requires from one-half to a full turn after seating to lock. Nut takes permanent set when seated and must be wrenched for further movement. Used primarily to hold conventional nonlocking nuts in place.

Materials: Steel.

Sizes: ¼ to 2 in.; Coarse threads, Class 2B. Body styles include regular and heavy series hex or square.

Source: MacLean-Fogg Lock Nut Co., Chicago, Ill.

(See Ad, Page 125)



M-F Speed Holding Nut No. 2

Form: One-piece, all-metal, free-spinning locknut. Lower arched surface of nut flattens when seated, causing top threads to move inward and develop a firm locking grip on the bolt.

Design Features: Spins freely until seated. Takes permanent set after tightening and becomes, in effect, a prevailing-torque type of locknut that must be wrenched for further movement. Meets proof load requirements for Grade 2 bolts.

Material: Steel.

Size: ¼ to ⅝ in.; Coarse and Fine threads, Class 2B. Body styles include regular square and hex.

Source: MacLean-Fogg Lock Nut Co., Chicago, Ill.

(See Ad, Page 125)

M-F Two-Way Locknut

Form: One-piece, all-metal, prevailing-torque locknut. Center portion of nut body is compressed to form elliptical

threads, while end portions of threads remain circular. Spring action of distorted section develops strong locking grip on bolt threads.

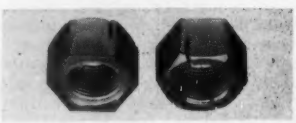
Design Features: Reusable. Spins freely until center locking section is engaged, then requires wrenching to final location on bolt. Nut is double chamfered and can be applied from either side, eliminating selective handling. Particularly suited for use with automatic feeding and assembly methods. Can be used as an adjusting nut or stop nut.

Materials: Low-carbon steel, brass, bronze, aluminum and stainless steel.

Sizes: No. 6 to ¾ in.; Coarse and Fine threads, Class 2B. Body styles include finished hex, finished hex jam, and hex open-end cap.

Source: MacLean-Fogg Lock Nut Co., Chicago, Ill.

(See Ad, Page 125)



Marsden Locknut

Form: One-piece, all-metal, free-spinning locknut. Upper part of nut is slotted to form several threaded segments. Bottom face is recessed so that seating surface is outside of thread pitch line. When nut is tightened against unyielding base, pressure on seating surface forces threaded upper segments to move radially inward to produce friction locking action.

Design Features: Reusable. Spins down easily until seated. Friction-locking action resists vibration. Area of thread contact, when locked, is greater than conventional nut. Can be readily adapted to high-speed assembly methods. Well established as rugged, dependable locknut.

Materials: Carbon steel, stainless steel, brass, bronze, and aluminum.

Sizes: ¼ to 1½-in.; UNC and UNF threads, Class 2B. Body styles include full and thick hex as well as many others.

Source: Produced under license by several manufacturers. Information, courtesy Industrial Fasteners Institute, Cleveland, Ohio. Photo, courtesy National Screw and Mfg. Co., Cleveland, Ohio.

(See Ads, Pages 138, 140)

Morse Hi-Load Spring Locknut

Form: Single-unit, all-metal, free-spinning locknut consisting of nut with conical-shaped lower section that mates with hardened steel washer. When nut is "bottomed," washer acts as spring to compress and lock nut threads against bolt under predetermined radial pressure.

Design Features: Reusable. Provides ac-

GRIPCO FASTENERS

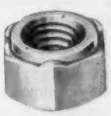
★ Improve Product Durability ★ Available from Stock ★ Lower Initial Cost

★ Reduce Assembly Time ★ Resist Stress and Vibration

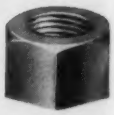
The Grip Nut Company, originator of the Gripco Top-locking feature, has had unsurpassed experience in the most exacting of all fields for the use of locking type nuts—railroad transportation. Grip Nut has been supplying lock nuts to American railroads and railroad car builders for over 50 years. All other major industries are represented among the regular users of Gripco Fasteners. Various types of working conditions and many difficult production problems have been met and overcome by Gripco Fasteners.

TOP-LOCK NUTS—All metal, steel, brass, aluminum or stainless. Same dimensions as standard nuts (both full and jam). Eliminates necessity for lock washers and other locking devices. Locks on the bolt-seating not necessary for locking action. Low in cost—stocked for immediate delivery—sizes #6 thru 1½", fine and coarse thread.

PILOT WELD NUTS—Circular locating collar for easy, quick positioning. 3 weld projections for a firm, non-rocking electrical connection. Furnished with or without Top-locking feature. Sizes—#6 thru ⅝", fine and coarse thread. 2 collar thicknesses for different gauge metals.

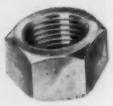


COUNTER SUNK WELD NUTS—Bottom of nut has countersink to eliminate fouling of threads by molten particles during welding—no retapping. Furnished with or without Top-locking feature. 3 weld projections for a firm, non-rocking electrical connection. Sizes—#8 thru ⅝" with fine and coarse threads.



STANDARD HEXAGON NUTS (Steel)—Finished and Heavy Series, full and jam dimensions. Finished Series, single chamfer washer face ¼" thru 1½". Finished Series, double chamfer ¼" thru ½" (full size only). Heavy Series, single chamfer washer face ¼" thru 1½". Other Metals to Special order.

TOP-LOCK HI-NUTS—For application requiring greater thread strength, such as U bolts for trucks, trailers, buses and cars. Sizes ⅜" thru 1¼"—fine thread only.



CENTER-LOCK NUT—Double Chamfered, with locking feature in center, can be applied from either end. Can be automatically fed. Speeds application. Will lock wherever it is turned on a bolt. Available in steel. Brass and aluminum on special order. Offered in finished series, double chamfered from #8 through ⅞" in fine or coarse threads. Heavy series made to special order only.

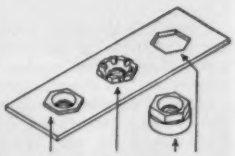
CLINCH NUTS—Hexagon Collar fits into hex hole preventing nut from turning. One pilot height for each size which clinches into normal gauge metal. Ideal for blind applications. Furnished with or without Top-locking feature. Complete range of sizes—#4 thru ⅝", fine and coarse thread.

All items listed are stock items, available for immediate delivery. The Grip Nut Co. will welcome an opportunity to work with product designers and production engineers on any detail of the application of Gripco Fasteners. Broadly experienced sales and engineering personnel are located in most sections of the country, ready to assist in the solution of your fastener problems.

Write or Phone for
GRIPCO FASTENERS CATALOGS
PRICE LISTS AND SAMPLES

CLINCH NUT APPLICATION DATA

A—Inner View. GRIPCO "Clinch" Nut ready to insert into hexagonal hole in metal. Shows "pilot" and hex hole before clinching.
This is how leading appliance manufacturers get fasteners into inaccessible places.
B—Cross-Section view after pilot has been clinched and bolt inserted. Can be locked at any point. (Non-locking nut can be supplied if preferred.)



Gripco Clinch Nuts can be either clinched solid for a rigid application or staked in with a six point staking punch to give a floating effect. This floating effect takes care of misalignment and makes the application of the bolt easier.

Automatic feeding and clinching machines as well as low cost portable clinching equipment is now available. Write for details.

GRIP NUT COMPANY

Offices and Factory: 103 Maple Ave. South Whitley, Indiana
Established 1904 Phone: South Whitley 112
A SUBSIDIARY OF HELI-COIL CORP., DANBURY, CONN.

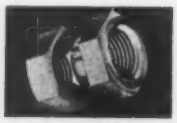
Representatives Located in: Cleveland, Ohio; Los Angeles and San Francisco, Calif; Detroit, Mich; Chatham, N. J.; Portland, Ore.; Chicago, Ill.; Salt Lake City, Utah; Milwaukee, Wis.; Louisville, Ky.; Davenport, Iowa; St. Louis, Mo.; Seattle, Wash.; Phoenix, Ariz.

curate control of bolt preload and can be assembled with conventional wrench. Resists severe vibration. Especially suited for difficult locations. Free spinning until seated.

Materials: Nut is low carbon steel; washer is hardened alloy steel.

Sizes: ¼ to ½-in.; Coarse and Fine threads.

Source: Morse Products Development Co., Los Angeles, Calif.



National Drake Locknut

Form: Two-piece, all-metal, free-spinning locknut consisting of lower working nut element with flexible, slotted crown and upper locking member. When upper member is tightened over flexible crown section, slotted sections are radially compressed to develop tight locking grip.

Design Features: Reusable. Provides high-force positive locking action. Load from working nut is not transferred to locking member as with conventional jam nut. Both members are free spinning until locked. Nut can be locked at any position on bolt by using two wrenches. Used primarily on rugged, heavy equipment where stress, shock, or vibration conditions are unusually severe.

Materials: Steel.

Sizes: ¼ to 1-in.; Coarse and Fine threads; Class 2B. Body style is hex.

Source: The National Screw & Mfg. Co., Cleveland, Ohio.

Nut Washers

Form: Single-unit, free-spinning locknut consisting of preassembled nut and lockwasher. Dished washer provides spring locking action when nut is seated.

Design Features: Reusable. Provides low-cost, rapidly assembled locknut. Washer turns freely on nut but can't drop off. Eliminates need for separate handling of washer and nut. Can be readily adapted to self-sealing washer designs.

Materials: Steel.

Sizes: No. 10 to 5/16-in.; Coarse and Fine threads.

Source: Mount Clemens Metal Products Co., Mount Clemens, Mich.

Nylok Locknut

Form: Single-unit, prevailing-torque locknut consisting of a standard hex metal nut body with radial nylon plug mounted in one side. Plug wedges mating threads in nut and screw together to provide locking action.

Design Features: Reusable. Provides secure vibration-resistant locking action. Will lock at any position on screw thread where plug is engaged. Nut can be threaded from either end, facilitating mechanical assembly and feeding methods. Works effectively on threads of varying pitch diameter. Nylon plug acts as dam to block flow of fluids or gases along threads. Useful temperature range is −70 to 250 F. Used to provide secure seated locking fastener or stop nut for screw adjustments.

Materials: Low-carbon steel, corrosion-resistant steel, brass, and aluminum.

Sizes: No. 4 to ¾-in.; UNC and UNF, Class 2B and 3B. Body styles include clinch and cap.

Source: The Nylok Corp., Elmira Heights, N. Y.

Palnut Locknuts

Form: One-piece, all-metal, free-spinning locknuts. As nuts are tightened against seat, spring-steel coned-thread engagement deflects to produce secure locking action.

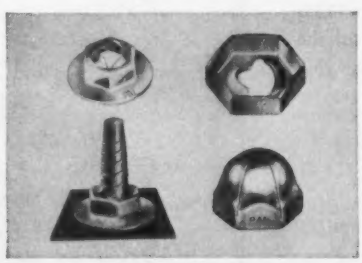
Design Features: Reusable. Can be used with all standard nut driving methods for rapid assembly. Light in weight. Double-locking spring action resists vibration. Locking action remains effective as long as center section is not unduly flattened by excessive torque. Maximum application temperature for spring-steel types is 400 F. Provides low-cost seated locknut for light assemblies or to lock standard nuts on highly stressed assemblies.

Materials: High-carbon spring steel.

Sizes: No. 2 to 2½-in.; NF, NC, pipe, and other threads. Body styles include hex, square, inverted, washer base, acorn, wing, and tension types.

Source: The Palnut Co., Mountainside, N. J.

(See Ad, Page 137)



Palnut Self-Threading Nuts

Form: One-piece, all-metal, thread-cutting, prevailing-torque locknuts. Stamped nut-body has two thread-forming teeth at center opening. Nut forms its own mating thread when driven onto unthreaded stud, rods, or similar members of malleable material. Spring action of nut body along with interference fit produced by thread forming operating provide strong prevailing-torque lock to hold nut firmly in position.

Design Features: Removable and reusable on same member. Provide 360-deg contact on flat or irregular work surfaces. Hex form fits all standard tools and shanks. Hold tight seated or unseated. Provide low-cost locking fasteners for lightly loaded, unthreaded studs, rods, and other similar members.

Materials: Spring tempered steel.

Sizes: ⅛ to ¼-in. nominal stud diameters. Body styles include integral washer, regular hex, and acorn types, with or without bonded-in plastisol sealer.

Source: The Palnut Co., Mountainside, N. J.

(See Ad, Page 137)

Pem Self-Clinching Locknut

Form: One-piece, all-metal, self-clinching, prevailing-torque locknut with clinching ring and semicircular locking jaws. When nut is pressed into prepared hole, sheet metal flows around back-tapered shank, securely locking nut in sheet with a flush fit on reverse side.

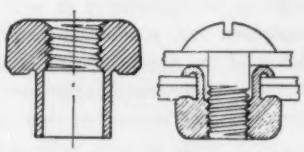
Design Features: Provides strong, permanent, self-locking thread surface in thin metal sections. Develops high torque and pull-out resistance. Suitable for use in aluminum, brass, copper, and cold-rolled steel sheets in thicknesses from 0.040-in. up. Semicircular locking jaws retain their inherent flexing action, preventing relaxation and loosening of fastener in severe service.

Materials: Steel and stainless steel.

Sizes: No. 4 to No. 10.

Source: Penn Engineering & Mfg. Corp., Doylestown, Pa.

(See Ad, Page 139)



Perma-Nut

Form: One-piece, all-metal, tubular rivet with internal threads in a drilled-through head. Sixteen serrations on underside of head bite into surface and prevent turning. Unthreaded, tubular section is set against work with roll clinch.

Design Features: Combines permanence of a rivet with disassembling advantage of a nut. Can be employed to permanently join two or more elements of a subassembly while providing an attachment nut. Serrations provide resistance to turning, or torque capacity, greater than strength of internal thread.

Materials: Steel, brass, and aluminum. Brass is not recommended with fine se-

DOT®
NYLON
PUSH-IN NUT

- Non-corroding
- Electrical insulator
- High pull-out resistance
- Straight legs won't distort thin, soft materials

This versatile fastening device snaps into place under finger pressure alone. Its straight legs permit easy insertion in square, punched holes while the tapered screw hole forces the legs apart when screw is inserted and ensures maximum pull-out resistance. Burrs do not impede the nut or prevent proper seating.

Ideal for use in virtually any type of thin-walled structure of sheet metal or plastic, the DOT Push-in Nut does not chip enamel surfaces, locks tightly without distorting the edges of the hole, resists vibration and serves as an excellent electrical and thermal insulator.

Suitable for use with #8 or #10 screws...locks in holes from .275″ to .292″ square...application thickness range: .030″ to .060″. Spacer type available with ½″ dia. head from ⅛″ to 1 1/32″ length in increments of 3/32″. Other types available in various sizes, round or square-headed, from 1/32″ to ⅛″ thick.

Engineering details and price information available on request.

CARR FASTENER COMPANY

Division of UNITED-CARR FASTENER CORPORATION

Cambridge 42, Mass.

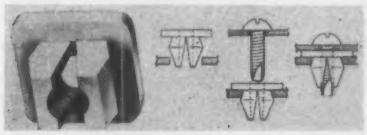
MAKERS OF DOT® FASTENERS

Offices in: Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Kalamazoo, Los Angeles, Louisville, New York, Philadelphia, Syracuse

ries threads.

Sizes: No. 3-48 through 1/4-120 thread sizes. Lengths from 1/8 to 5/8 in.

Source: Tubular Rivet and Stud Co., Quincy, Mass.



Plasti-Grommet

Form: One-piece, all-plastic snap-in locknut. It is snapped into prepared hole and locked in place by tapping screw.

Design Features: Provides low-cost, locking screw receptacle for blind or open locations that is vibration resistant. Develops high holding strength and load capacity.

Will not mar surface finishes. Is noncorrosive and electrically nonconductive.

Materials: Nylon.

Sizes: No. 6 to 3/8 in., thread-cutting tapping screws. Grip lengths up to 3/16 in. Body styles include several round and square head designs.

Source: Fastex Div. of Illinois Tool Works, Des Plaines, Ill.

P-M Nut

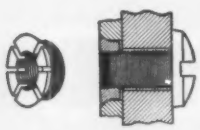
Form: One-piece, all-metal, free-spinning locknut. Compression of arched base of nut when screw is tightened applies tension and radial pressure through the boss at four points on the threads of the screw to develop locking action.

Design Features: Reusable. Turned down corners of nut grip seating surface while screw is being tightened, eliminating need for wrench holding. Concave shape of base facilitates assembly of screw. Provides low-cost rapidly assembled, vibration-resistant locknut.

Materials: Hardened and spring-tempered high-carbon steel.

Sizes: No. 6-32 to 1/4-28. Body style is square.

Source: P-M Nut Div., The Waterbury Pressed Metal Co., Waterbury, Conn.



Pow'Rgrip Locknut

Form: One-piece, all-metal, self-clinching, self-locking nut. One end is cone shaped and slotted; other end has knurled surface. Nut is partially pressed or driven into drilled and countersunk hole and held in position by gripping action of knurls. When fastener is inserted in knurled end and tightened, insert is further drawn into hole, forcing slotted cone segments inward to develop locking action.

Design Features: Retains locking action when screw is removed and reassembled. Locking forces are developed by interference of slotted section, which has cone angle of 63 degrees, with 60 degree countersunk seat. Used to provide quickly assembled tapped hole in plate or "soft" metal members of at least 3/16-in. thickness.

Materials: Steel.

Sizes: No. 6 to 5/16-in., Coarse and Fine threads.

Source: Allmetal Screw Products Co. Inc., Garden City, N. Y.

Press-Nut

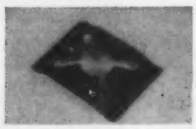
Form: One-piece, all-metal, self-clinching nut. Nut body has a large serrated flange separating a small plain flange at one end and a slotted and tapered section at the other. Small flange is pressed or driven into prepared hole, seating face of serrated flange against part surface. Cold flow of material into space between flanges locks nut in place while teeth of serrated flange broach themselves into the part surface to prevent rotation.

Design Features: Provides a strong flush-mounted tapped hole in sheet metal or plate members. Suitable for material thicknesses of 0.020 in. and greater. Can be assembled from one side in blind locations. Locking action resists high torque and pull-out loads.

Materials: Stainless steel and Ledloy.

Sizes: No. 2 to 1/4-in.; Coarse and Fine threads. Body styles include selflocking and nonlocking internal threads.

Source: Rosan Inc., Newport Beach, Calif.



Prestole Push-On Nut

Form: One-piece, all-metal spring-action locknut for unthreaded stud members. Nut is pushed on over stud surface. Compression of arched base coupled with inward "biting action" of two gripping elements produces firm spring-tension lock when nut is seated.

Design Features: Reusable. Adaptable to high-speed assembly methods. Locking action is not affected by variations up to 1/64 inch in stud diameter. Can be used on any material. Provides low-cost high-production locking fastener for light assemblies with stud elements.

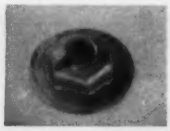
Materials: Coldrolled or spring steel.

Sizes: 3/32 to 7/16 in. stud diameters.

Source: Prestole Corp., Toledo, Ohio

Prestole Self-Threader

Form: One-piece, all-metal thread cutting, prevailing-torque locknut. Nut is assembled to an unthreaded stud by power driver or hand tool, cutting or forcing its own thread as applied. Interference fit produced by thread forming action holds nut firmly in place.

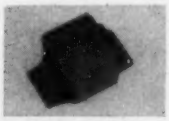


Design Features: Reusable. Provides low-cost rapidly assembled locking fastener for lightly loaded unthreaded studs, rods, and other similar members. Has spring take-up for positive holding action. Prevailing-torque locking feature prevents back off under vibration.

Materials: Spring steel.

Sizes: 1/8 in. and 3/16 in. studs. Body styles include model with integral sealing compound.

Source: Prestole Corp., Toledo, Ohio.



Prestole Snap Nut

Form: One-piece, all-metal, prevailing-torque locknut made as stamping. Nut is snapped into square hole in panel or thin section. Spring arms, which expand when screw thread enters, bind against root of thread to provide locking action.

Design Features: Reusable. Resists vibration. Spring tension of nut prevents "dead-tight" fastening, thus avoiding marring of finished surfaces. Can be used with either screws or studs. Provides low-cost locking fastener for blind locations.

Materials: Coldrolled or spring steel.

Sizes: No. 6 to 3/16 in. sheet-metal screw threads. Body styles include light, heavy-duty, and stud types.

Source: Prestole Corp., Toledo, Ohio

Prestole Spring-Action Fasteners

Form: One-piece, all-metal, free-spinning locknuts made as stampings. Spring-action of thread engaging element, which develops 360-degree clamp on root of screw thread, produces firm locking grip.

Design Features: Reusable. Provides low-cost high-production locking fastener. Resists loosening effect of vibration. Thread engaging element provides natural screw lead. Adaptable to high-speed assembly methods.

Materials: Spring steel or cold-rolled steel.

Sizes: No. 6 to No. 14; sheet-metal screw threads. Body styles include weld, bridge spacer, flat, C-clip, J-clip, tandem, and others.

Source: Prestole Corp., Toledo, Ohio.

Push-In Nut

Form: One-piece, molded nylon push-in locknut. It is pushed into prepared hole

and locked in place by tapping screw.

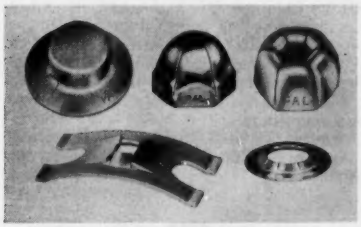
Design Features: Provides low-cost, locking screw receptacle for blind or open locations that is vibration resistant. Develops high holding strength and load capacity. Will not mar surface finishes. Is noncorrosive and electrically nonconductive.

Material: Nylon.

Sizes: No. 8 and No. 10 sheet-metal (tapping) screws. Mounting hole size is 0.290 by 0.281 in. Material thickness range from 0.030 to 0.060 in. Body styles include round, square, and rectangular head designs.

Source: Carr Fastener Co., Div. of United-Carr Fasteners Corp., Cambridge, Mass.

(See Ad, Page 129)



Pushnut

Form: One-piece, all-metal, spring-action locknuts for unthreaded studs and rods. Nuts are pressed onto unthreaded surface. Spring-clamping action of teeth around circular nut opening provides firm locking grip.

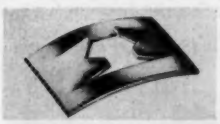
Design Features: Reusable. Adaptable to high-speed assembly methods. Resist vibration. Provide low-cost rapidly assembled locking fasteners for unthreaded rod, axles, shafts, and pins. Lend themselves to knock-down assembly.

Materials: Spring-tempered steel.

Sizes: 0.120 to ½-in. rod diameter. Body styles include closed and open-end acorn, arched rectangular, washer cap, and round flat.

Source: The Palnut Co., Mountainside, N. J.

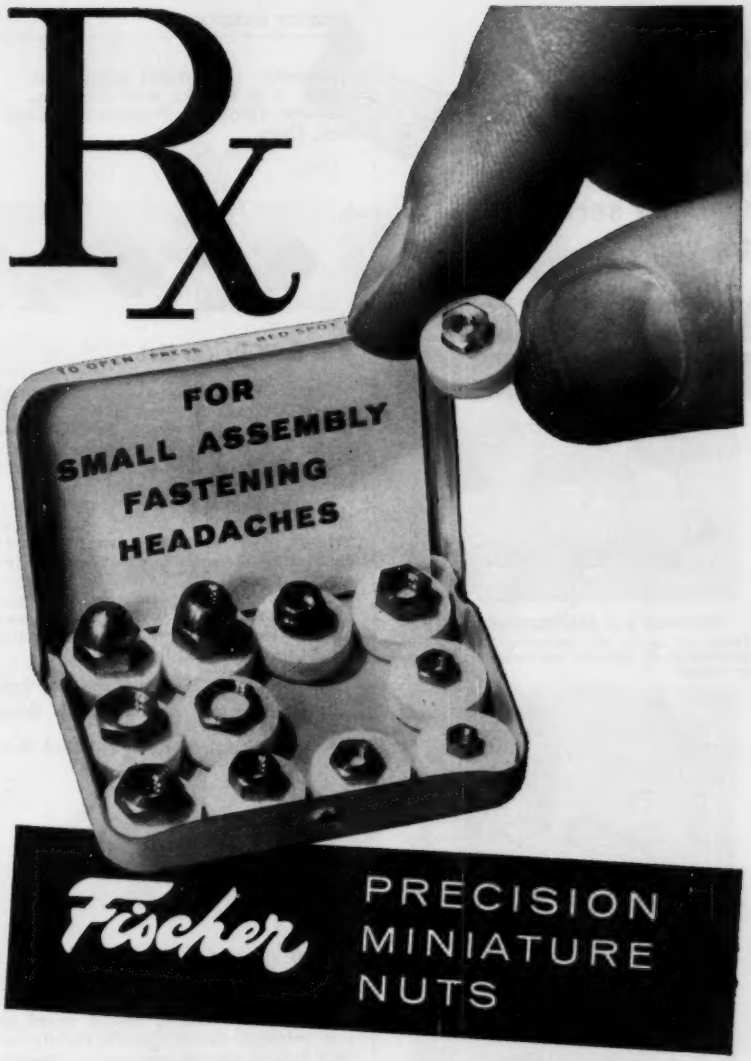
(See Ad, Page 137)



Push-On Speed Nut

Form: One-piece, all-metal, spring-action locknut for unthreaded parts. Nut is pushed on over unthreaded surface. Compression of arched base coupled with inward "biting" action of two prongs produces firm spring tension lock when nut is seated.

Design Features: Reusable. Adaptable to high speed assembly methods. Resists vibration. Provides low-cost high-production locking fastener for lightly loaded unthreaded studs, rivets, or other similar parts.



In miniaturized products, fastening delicate components securely in place can be a major production "headache". If the fasteners used are not accurate, uniform and easy to install, assembly operations become a costly nightmare.

To help solve this critical problem, Fischer is supplying precision turned miniature nuts that are tapped square (within 1°) to Class 2 tolerances, with lengths and diameters held to +.000" and —.005". Sizes range from ⅛" hexagon and include standard, special and odd size or shape nuts with standard or special threads from No. "0". In addition, all Fischer nuts are furnished burrless, cleaned and ready to use.

Whatever your application, if you require extreme accuracy and prompt "on schedule" delivery at competitive prices . . . let Fischer quote your next miniature nut order.

WRITE TODAY FOR ADDITIONAL MINIATURE DATA.

there's no premium for precision at

Fischer SPECIAL MFG. CO.

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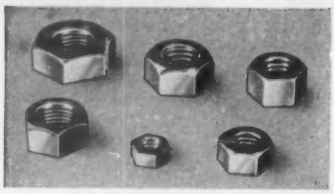
From
WEMPY
a complete personalized fastener service for you

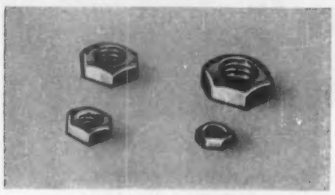
SERVICE . . . UNIFORMITY

ECONOMY . . . DEPENDABILITY

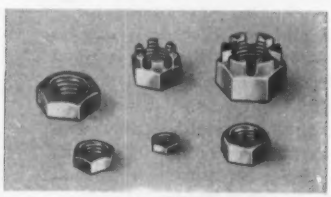


FINISHED and SEMI-FINISHED NUTS
From ¼" up to and including 2". Any combination of countersink and chamfer, Hexagon or Square.

SPECIAL NUTS
To suit customers' specifications. Engineering Service available.



MACHINE SCREW NUTS
#0 up to and including ⅜" Single Chamfer, Double Chamfer, Single or Double Countersink, Hexagon or Square.



AN NUTS
AN 310, 315, 316, 320, 335, 340, 341, 345, and six digit numbers.

Materials available: Steel, Brass, Stainless Steel, Aluminum, Monel and Silicon Bronze..

Also available: Screws — #0 up to and including ⅜".

SIMPLE OR SPECIAL . . .
YOU'RE ALWAYS AHEAD WITH WEMPY

Send for Free Catalog

The Westfield Metal Products Co., Inc.
1030 Lower Union St., Westfield 1, Mass.

Circle F-15 on Page 97

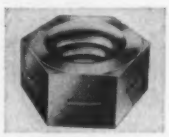
Materials: Heat-treated spring steel.
Size: 3/64 to 2-in. stud diameters.
Source: Tinnerman Products Inc., Cleveland, Ohio.
(See Ad, Page 117)

R B & W Delrin Nut

Form: One-piece, all-plastic, prevailing-torque locknut. Nut has plain through hole and forms its own thread when turned onto bolt. Thread forming action develops strong friction grip on bolt threads.
Design Features: Reusable. Provides low-cost, lightweight locking fastener for light-duty service where corrosion resistance and decorative appearance are required or desirable. Depending on size, nuts develop holding strength in straight tension from 500 to 700 lb, prevailing-torque from 8 to 14 lb-in., stripping torque from 20 to 30 lb-in.
Material: Delrin.
Sizes: No. 10 to ¼ in. nominal bolt diameters; Coarse and Fine threads. Body style is open-end acorn.
Source: Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y.

RB&W Open-End Acorn

Form: One-piece, all-metal, prevailing-torque locknut. Side of nut is staked at two points to distort threads slightly for tight locking grip on bolt.
Design Features: Reusable. Particularly suited for applications where decorative appearance and rounded contours are desirable. Provides continuing locking grip when staked section is engaged.
Materials: Steel and aluminum.
Sizes: No. 10, ¼, and 5/16 in.
Source: Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y.

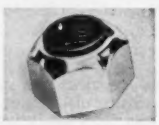


Reverse Lock

Form: One-piece, all-metal, prevailing-torque locknut. Threads at center section of nut are deflected inward to produce friction-locking grip on bolt.
Design Features: Reusable. Provides continuous locking grip on bolt when center section is engaged. Reversible; starts freely when threaded onto bolt from either end. Resists vibration. Can be used as a stop nut or seated locknut.
Materials: Steel, brass, aluminum, or stainless steel.
Sizes: All standard machine screw threads; Class 2B. Nut style is hex.
Source: Jacobson Nut Mfg. Corp., Kenilworth, N. J.
(See Ad, Page 141)

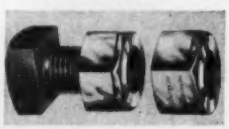
Robin Clinch-it

Form: One-piece, all-metal, clinch nut for unthreaded studs. Nut is placed over end of unthreaded stud and sides are squeezed together by pliers or simple installation tool. Edges of diamond pattern hole in nut bite into stud surface and sides of nut are compressed against part surface to draw stud up tight and lock assembly.
Design Features: Provides low-cost, easily installed locknut for assembly of ornamental studs to sheet metal. Can be readily adapted to high-speed assembly methods. Locking action does not depend on spring effect for secure grip. Resists vibration. Does not require firm backing of attached part for tight joint.
Materials: Carbon steel, stainless steel, and aluminum.
Sizes: 1/16 to 3/16 in. stud diameters.
Source: Robin Products Co., Warren, Mich.



Security Locknut

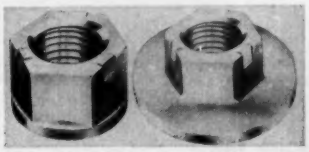
Form: Single-unit, all-metal, prevailing-torque locknut consisting of stantard nut body with locked-in, threaded, elliptical spring-steel insert. Elastic spring action of insert develops high radial locking pressure on threads of bolt.
Design Features: Reusable. Locks in any position on bolt when insert threads are engaged. Loads are carried by nut body only, insert acts solely as lock. Rotation of insert is prevented by projecting ear. Resists vibration and shock.
Materials: Nut body is steel.
Sizes: 7/16 to 3-in. Body styles include full and jam hex in finished and heavy types, cap, and square.
Source: Security Locknut Corp., Melrose Park, Ill.
(See Ad, Page 138)



Self-Retaining Locknut

Form: One-piece, all-metal, prevailing-torque locknut. Upper portion of nut has horizontal slit and develops spring tension when turned onto bolt to provide firm friction lock.
Design Features: Reusable. Starts freely by hand and then is wrench tightened when upper part engages bolt. Provides a low-cost secure seated locknut or stop nut.

Materials: Steel.
Sizes: ¼ to 2 in.; Coarse and Fine threads.
Source: Columbia Nut & Bolt Co. Inc., Bridgeport, Conn.



Shakeproof Lokut

Form: One-piece, all-metal, prevailing-torque locknut. Upper part of nut wall has shear depressions at three points causing top threads to project inward. Radial compression forces developed by deflected threads produce powerful friction locking action on bolt.
Design Features: Reusable. Nut starts freely, then wrench is used. Provides continuous clamping force on bolt when deflected threads are engaged. Locking action is unaffected by temperature changes, bolt stretch or variation of work pressure. Ideally suited for applications involving spring compression or where fragile work surface makes it impossible to draw nuts down for surface locking action.
Materials: Steel.
Sizes: No. 8 to ½-in.; Coarse and Fine threads, Class 2B. Body style is hex.
Source: Shakeproof Div. of Illinois Tool Works, Elgin, Ill.

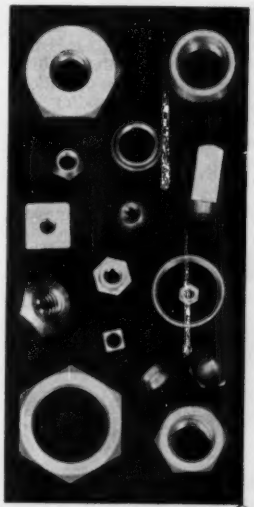
Speed Nut

Form: One-piece, all-metal free-spinning locknut made as stamping. Compression of arched base coupled with inward gripping pressure of two arched prongs on screw thread produces secure locking action as nut is seated.
Design Features: Reusable. Resists loosening effect of vibration. Adaptable to high-speed assembly techniques. Locking action compensates for thread tolerance variations. Provides low-cost, high-production, vibration-resistant locking fastener.
Materials: Heat-treated spring steel.
Sizes: No. 2 to ⅝-in.; machine screw, sheet-metal screw, and Acme bolt threads. Body styles include flat, W, J, U, anchor, latch, and many other types.
Source: Tinnerman Products Inc., Cleveland, Ohio.

(See Ad, Page 117)

Spring Locking Nut

Form: One piece spring steel snap-in nut made as stamping, with a screw impression.
Design Features: Reusable. Provides snap-in female thread. Self retaining to panel. Assembly of screw spreads open ends of clip to create spring lock.



AS SPECIALISTS IN PRECISION NUTS . . . both brass and aluminum . . . we can help resolve your fastening or assembly problems by supplying *uniformly accurate turned nuts to your exact specifications.* To date, we have furnished more than 3,457 different types of special or odd size nuts, including miniatures, to customers making widely diversified products. Their satisfaction with our over-all performance is eloquently confirmed by repeat orders . . . plus orders for new items!

As the leading producer of turned nuts, we specialize in reliable "on schedule" deliveries and competitive pricing in addition to premium quality. That is why you get better service . . . faster . . . from Fischer.

FOR DETAILS, WRITE FOR CATALOG FS-1000 AND PRICE LISTS.

there's no premium for precision at

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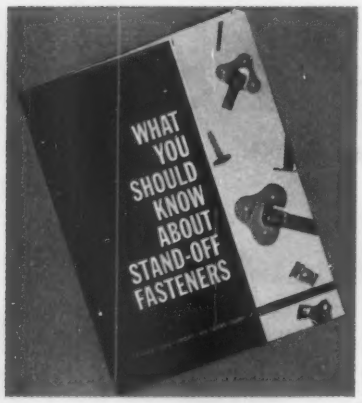
FISCHER SPECIAL MFG. CO.
451 MORGAN STREET CINCINNATI 6, OHIO

8815-FS

Circle F-12 on Page 97



WHAT YOU SHOULD KNOW ABOUT STAND-OFF FASTENERS

for tubing • piping • conduits • wire bundles • support of equipment and instruments.

FREE! NOT A SALES BOOKLET

An objective analysis in the fastener field

CONTENTS:—

- Small Fasteners are important business
- Advantages and disadvantages of each type
- Advantages and disadvantages of various fastener materials
- Causes of failures of stand-off fasteners
- When is strength important?
- Weight saving
- Awkward shapes
- A minimum of drilling in structural material is desirable, "The Swiss Cheese Effect"
- When to use special types
- Installation costs — the bugaboo. Tips on how to cut costs.
- High cost of unnecessary re-work
- Removal — a headache or a cinch
- How to compare costs of fasteners
- How to select stand-off fasteners

Phone or mail this COUPON TODAY to the nearest office

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Gentlemen:
Please send me, without charge, your authoritative booklet on stand-off fasteners.

Name_____

Address_____

Firm_____

Engineer_____ Student_____ Other_____

Circle F-13 on Page 97

Material: Spring steel.
Size: No. 14 spaced thread series.
Source: Prestole Corp., Toledo, Ohio.

SPS Featherweight Locknuts

Form: One-piece, all-metal, prevailing-torque locknut. Upper threads are deformed into elliptical shape to develop locking action.

Design Features: Reusable. Provides lightweight locknut with high strength-weight ratio. Has reduced wrenching height and bearing surface. Rated tensile strengths up to 260,000 psi. Maximum application temperature is 1600 F.

Materials: Alloy steel and other materials, depending on stress level and temperature ratings.

Sizes: No. 4 to ½ in.

Source: Standard Pressed Steel Co., Jenkintown, Pa.

SPS Swage Nut

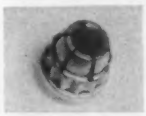
Form: One-piece, all-metal, self-clinching type nut with prevailing-torque locking feature. Bottom section of nut has reduced diameter neck with retaining groove and knurled swage ring. Bottom ring of neck fits into hole stamped or drilled in sheet metal part. Nut and metal are squeezed between flat, parallel plates to flow metal into retaining groove and around swage ring in neck of nut. Knurls in swage ring resist nut rotation. Prevailing-torque feature locks screw fasteners.

Design Features: Provides high-strength, load-bearing threads in thin-gage sheet-metal parts. Can carry tensile loads up to 160,000 psi or more. Minimum displacement of metal in swaging operation eliminates deformation or bending of sheet. Usable in metals of Rockwell C hardness up to 25. Can be installed with standard presses.

Materials: Alloy steel.

Sizes: No. 2 to ½ in., Coarse and Fine threads, Class 2B. Material thicknesses from 0.020 to 0.250 in.

Source: Standard Pressed Steel Co., Jenkintown, Pa.



Star-Lok

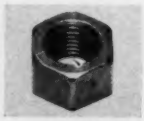
Form: Single unit, all-metal, prevailing torque locknut. Upper slotted section of nut is radially loaded to develop firm locking grip on bolt.

Design Features: Reusable. Provides high-strength locknut. Designed to reduce wrenching clearance and to minimize width of flanges, thus permitting higher torque.

Materials: Steel, 18-8 stainless steel, and A-286 and M-252 superalloys.

Sizes: No. 10 to ½ in. Body style is 12-point external wrenching.

Source: Boots Aircraft Nut Corp., Norwalk, Conn.



Stollock Nut

Form: One-piece, all-metal, prevailing-torque locknut. Center portion of nut body is indented to form three internal steel pads which develop strong friction-locking grip on bolt threads.

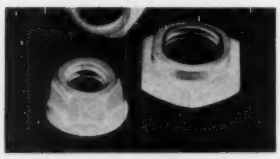
Design Features: Reusable. Provides continuing friction locking grip when center section is engaged. Starts freely on bolt when threaded from either side and can be readily adapted to manual or machine feeding and assembly methods. Nut bore is not out of round. Nut body is not distorted.

Materials: Mild steel, brass, or aluminum.

Sizes: No. 10 to ⅝ in.; Coarse and Fine threads. Body style is finished-full or light-dimension hex.

Source: Zimmer-Lightbody Industries Inc., Detroit, Mich.

(See Ad, Page 138)



Stover Locknut

Form: One-piece, all-metal, prevailing-torque locknut. Top portion of nut is compressed so that upper threads are elliptical while bottom part remains circular. Distorted section produces firm, positive locking grip on bolt.

Design Features: Reusable. Develops high tension-to-torque ratio. Can be started by hand, then run up with wrench. Provides strong vibration-resistant locking action even when bolts do not protrude through nut. Can be adapted to high-production assembly methods.

Materials: Low-carbon and heat-treated medium-carbon steel.

Sizes: ¼ to 2 in.; Coarse and Fine threads. Body styles include automation, flange, and thin, finished, and heavy hex collar designs.

Source: The Lamson and Sessions Co., Cleveland, Ohio.

Tensilock Nut

Form: One-piece, all-metal, free-spinning locknut with enlarged flange base. Face of flanged base has ratchet-like teeth on outer rim and a circular groove in center. Teeth imbed in part surface when nut is seated.

Design Features: Reusable. Adaptable to high-speed assembly techniques. Groove

in flange face increases diaphragm action to help maintain residual tension in bolt assembly. Can take higher tightening torque than standard machine screw nut. Ratchet teeth are angled on the advancing side to facilitate tightening, but are vertical on the back side to resist loosening. Torque required to loosen nut is 150 per cent of application torque. Locking action resists severe vibration or cyclic heating and cooling. Develops high tension-to-torque ratio. Wide flange base can span oversize clearanced holes.

Materials: Carburized steel.

Sizes: No. 6 to ⅜ in. Body style is hex.

Source: Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y.

Tenz-Nut

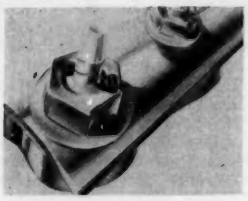
Form: Single-unit, all-metal, free-spinning locknut consisting of preassembled standard nut and cupped-type spring washer.

Design Features: Reusable. Adaptable to high-speed machine assembly methods. Washer is held securely to nut, yet is free to rotate under compression. Eliminates separate handling of nut and washer during assembly. Conical washer provides strong reactive spring pressure to resist loosening of nut on bolt. Particularly suited for use on polished or finished surfaces where marring of base metal is to be avoided. Can be readily adapted to self-sealing lockwasher designs.

Material: Carbon steel.

Sizes: No. 5 to ⅜ in., NC and NF threads. Nut body styles are machine screw and finished hex.

Source: Reliance Div., Eaton Mfg. Co., Massillon, Ohio.



Thread Cutting Locknut

Form: One-piece, all-metal, thread-cutting, prevailing-torque locknut. Nut body is hex and can be assembled with standard hand socket wrench or nut-runner. Interference fit produced by thread-cutting action holds nut firmly in position.

Design Features: Reusable. Provides low-cost locking fastener for lightly loaded unthreaded studs, rods, and other similar members. Resists loosening by vibration. Provides spring-takeup action and pulls up tight without backup on flat or contoured surfaces. Particularly suited for holding die-cast or cold-forged nameplates, emblems, and trim against sheet-metal surfaces.

Material: Steel.

Sizes: ⅛, 3/16, and ¼ in. nominal stud diameters. Body styles include designs with and without sealer.

Source: Carr Fastener Co., Div. of

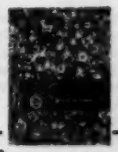
ON YOUR FASTENING PROBLEMS!

If slow-downs in assembly operations are jinxing your production schedules, you can be sure they aren't caused by "voodoo"! But what about the fasteners you are using? If they are not accurate and uniform, they can cause costly bottlenecks.

Fischer helps solve fastening problems by supplying *precision turned brass and aluminum nuts* . . . standards, specials, odd sizes or shapes and miniatures . . . to meet individual needs. And to assure reliable performance, all Fischer turned nuts are produced to closer tolerances than required by American Standard B18.2-1955 specifications. Fischer also specializes in dependable "on schedule" deliveries and competitive pricing. *That's why FISCHER is your best source for precision nuts.*

TURNED NUTS Fischer SPECIAL MFG. CO. SINCE 1906

FOR DETAILS, SPECIFICATIONS AND PRICES . . . WRITE FOR CATALOG FS-1000.



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CITY_____ ZONE___ STATE_____

8823-FS

Circle F-14 on Page 97

TAKE A CLOSER LOOK

Discover the advantages of the new TRU-LOK aluminum self-locking nut •

• Patent Nos. 2363662 and 2363663

- MEETS ALL PERFORMANCE REQUIREMENTS OF MIL-N-25027 (160,000) PSI TO 550°F.
- CAN BE REUSED EXTENSIVELY WITH THE ABSOLUTE ELASTIC MEMORY OF A STAINLESS STEEL SPRING.
- MAINTAINS CONSTANT VIBRATION-PROOF POSITION ANYWHERE ON THE MALE MEMBER . . . LOCKING CONSTRUCTION IS INBOARD FROM THE ENDS.
- POSSESSES SMOOTH UNVARYING TORQUE . . . POSITIVE, ACCURATELY CONTROLLED PRESSURES ARE FORMED INTO THE SPECIFIC CONFIGURATION OF THE MIDDLE WINDING.
- VIRTUALLY ELIMINATES WEAR, SEIZURE, GALLING OR DEFORMATION OF MATING THREADS . . . MAKING TORQUE MEASUREMENT A MORE MEANINGFUL PARAMETER AND REDUCING THE POSSIBILITY OF CONTAMINATION TO SENSITIVE INSTRUMENTS AND EQUIPMENT.
- EFFECTS HIGH STRENGTH-TO-WEIGHT RATIOS

Write for your copy of Bulletin #3002 and #3003

WALTHAM
PRECISION INSTRUMENT COMPANY
Waltham 54, Massachusetts

Circle F-17 on Page 97

United-Carr Fastener Corp., Cambridge, Mass.

Triangular Nut

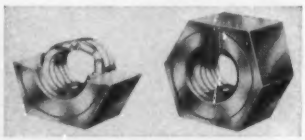
Form: One piece, all-metal free-spinning locknut made as stamping. Nut body is dished. Spring clamping action of edges of circular opening provides firm locking grip on screw when nut is seated.

Design Features: Reusable. Resists impact and vibration. Dished body flattens under torque, providing equal load distribution against part to be held. Can be adapted to high-speed assembly methods. Provides low-cost, high-production locknut for lightly loaded assemblies.

Materials: Carbon spring steel. beryllium copper, phosphor bronze, stainless steel.

Sizes: No. 6 to ¼-in.; Coarse and Fine threads.

Source: Waldes Kohinoor Inc., Long Island City, N. Y.



Tru-Lok

Form: Single-unit, all-metal, prevailing-torque locknut consisting of metal nut body with internal coil of diamond shaped wire that provides standard 60 deg threads. Loop at center of wire coil is formed into constricting polygon shape to produce locking action on bolt threads.

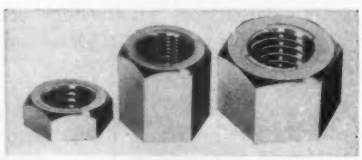
Design Features: Reusable. Provides continuing locking grip when center of wire coil is engaged. Starts freely on bolt when threaded from either end. Meets performance requirements for MIL-N-25027 250 and 550 F nuts. Corrosion resistant. Provides high strength-to-weight ratio and accurate torque control. Resists vibration, seizure, and galling or deformation of mating threads.

Materials: Nut body is 2024 (24ST-6) aluminum, wire coil is 18-8 stainless steel.

Sizes: No. 4 to 7/16-in.; Coarse and Fine threads; Class 3B. Nut style is hex.

Source: Waltham Precision Instrument Co., Waltham, Mass.

(See Ad, Page 136)



Uni-Torque Locknut

Form: One-piece, all-metal, prevailing-torque locknut. Top threads of nut are deflected slightly out of true helix shape to produce locking action on bolt.

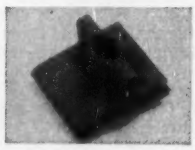
Design Features: Reusable. Starts freely on the bolt until deflected threads are reached, then requires wrenching to final position. Will lock in any position on bolt, provided a minimum of 1 to 1½ bolt threads protrude beyond the top of the nut.

Materials: Steel, brass, bronze, aluminum and stainless steel.

Sizes: No. 6 to 2 in.; Coarse and Fine threads. Body styles include finished and heavy series full and jam hex.

Source: MacLean-Fogg Lock Nut Co., Chicago, Ill.

(See Ad, Page 125)



Vi-Tor

Form: One-piece, clip-on pervailing-torque locknut which assembles over the edge of panels or thin sections.

Design Features: Provides a lowcost, easily installed threaded section. Prevailing-torque locking action prevents loosening under vibration. Used on panels or thin sections where edge fastening is required.

Materials: Spring steel.

Sizes: ¼ to 5/16 in.; Coarse and Fine threads.

Source: Prestole Corp., Toledo, Ohio.

V-Lock Teenut

Form: One-piece, all-metal, prevailing-torque locknut. Body of nut is in form of threaded sleeve with flanged base. Top of sleeve, which has V-shaped notch, is compressed inwardly to provide wedge locking action on engagement with threads of bolt.

Design Features: Reusable. Provides a secure, seated locknut or stop nut. Withstands vibration. Provides high-strength-weight ratio. Maximum application temperature is 550 F.

Materials: Low-carbon, cold-rolled steel.

Sizes: No. 8 to ½-in.; UNC and UNF threads, Class 2B. Body styles include both locking and nonlocking types, as well as various sleeve and flange designs.

Source: Carr Fastener Co., Div. of United-Carr Fastener Corp., Cambridge, Mass.

Weightmaster Locknuts

Form: One-piece, all-metal, prevailing-torque locknut. Upper threads are deformed into elliptical shape to develop locking action on bolt.

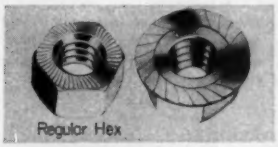
Design Features: Reusable. Provides lightweight locknut designed for use with bolts having tensile strengths in 160,000-180,000 psi range. Locks in any position

on bolt when elliptical thread section is engaged. Maximum application temperature is 550 or 900 F, depending on nut material.

Materials: Heat-treated steel or A-286 corrosion-resistant steel.

Sizes: No. 2 to ½ in., Coarse and Fine threads, Class 3B. Body styles include one and two-lug anchor arrangements, internal-wrenching, twelve-point, and hex designs.

Source: Voi-Shan Mfg. Co., A Div. of Voi-Shan Industries Inc., Culver City, Calif.



Whiz-Lock Nut

Form: One-piece, all-metal, free-spinning locknut. Ratchet-like teeth on the convex base of the nut grip part surface when nut is seated to provide firm locking action.

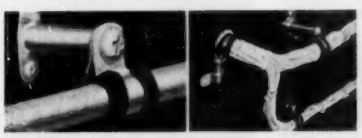
Design Features: Reusable. Locking element is contained within the nut body with no projecting teeth. Eliminates separate handling of nut and lockwasher. Requires more torque to remove than to apply. Directional shape of teeth permits torquing to high tension. Tooth action against part surface is burr free. Resistant to vibration.

Materials: Case-hardened steel.

Sizes: No. 6 to ⅝ in., Class 2B threads. Body styles include hex and hex flange.

Source: MacLean-Fogg Lock Nut Co., Chicago, Ill.

(See Ad, Page 125)



WSI Self-Locking Fasteners

Form: Single unit, all-metal, prevailing-torque anchor or plate-type locknut. It consists of a threaded nut barrel and mounting flange. Locking type wire-thread insert, mounted in barrel, provides firm locking grip on screw. Nut flange is mounted to panel or structure by rivets.

Design Features: Provides high-strength, self-locking, stand-off fastener suitable for medium to light loads. Particularly suited for attachment of instrument panels, harness mounting, and shock mounting of delicate equipment. Wire-thread insert maintains constant spring pressure on screw threads. Resists vibration and shock. Locking coil resists seizing, galling, and stripping of screw. Single-unit construction facilitates installation.

Materials: Body is forged or extruded aluminum alloy. Insert is stainless steel.

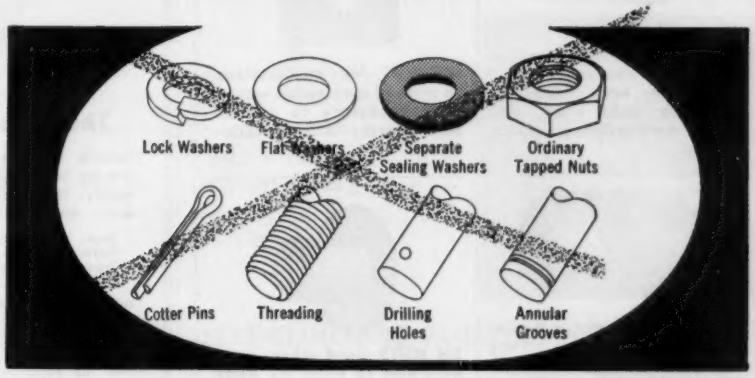
Sizes: No. 6-32 and No. 10-32, NC and NF internal threads, Class 2B. Barrel lengths from 0 to 3 in. Styles include light duty, heavy duty, double-ended fitting, and right-angle light duty.

Source: Western Sky Industries, Hayward, Calif.

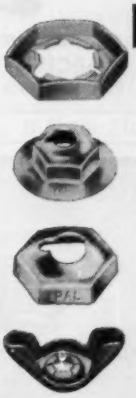
(See Ad, Page 134)

PALNUT® LOCK NUTS and FASTENERS *Eliminate*

one or more of these assembly parts or operations



– and provide compact, vibration-proof assemblies



PALNUT Lock Nuts for Threaded members

Spring tempered steel Palnuts, with the dependable double-locking thread form, are available in many stock types and sizes to meet practically any assembly need. Here are typical advantages:

- **Low cost**—less than other locking devices, often less than plain nuts.
- **Easy, fast assembly** with ordinary manual or power tools, extra fast with Palnut Magnetic Wrenches.
- **Save Parts.** One Palnut replaces 2, 3, even 4 parts according to application.
- **Save Space** by eliminating auxiliary parts.
- **Save Weight**—up to 85% reductions in fastener weight.
- **May be removed and re-used.**

FASTENERS for Unthreaded Studs, Rods, Pins, etc.

SELF-THREADING NUTS

Save threading costs. Form their own deep, clean threads while tightening on studs of any malleable material, including aluminum or zinc die-cast; also rods, shafts, wire or pins of steel, aluminum, brass or plastic. Fast assembly with standard tools. Vibration-proof grip, whether seated or unseated. Remove and reuse on same studs. Sizes for 1/8", 5/32", 3/16" and 1/4" dia. Write for Bulletin 585-A.

PUSHNUT® FASTENERS

Simply push on unthreaded studs, rod, wire or rivets. Strong spring grip resists removal. Save threading, grooving, drilling for cotter pins. Low in cost, fast assembly. Many types and sizes.

Write for literature and free samples, stating type, size and application.

PALNUT®

THE PALNUT COMPANY

Division of UNITED-CARR Fastener Corp.

75 Glen Road, Mountainside, N. J.

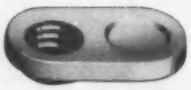
Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

LOCK NUTS and FASTENERS

Quick, secure fastening at low cost

Circle F-18 on Page 97

OHIO WELD NUTS



(Patent Applied For)

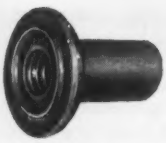
XN NUT with precision pilot and recessed target electrode area. Provides optimum weld even with light spot-welding equipment.

WS NUT For applications on rugged assemblies where it is necessary to anchor nut securely in blind location.

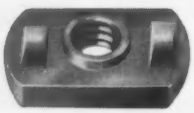
PN NUT Used where a pilot for easy locating, a strong weld and space limitations are important factors, ideal for use in confined corners, flanges and narrow channels.

RH NUTS Used where it is desirable to have the body of the nut go through the sheet or where extra long thread engagement is needed.

WF NUTS Used where the nut serves a mounting purpose or greater thread engagement is required than is normally provided by other type weld nuts.

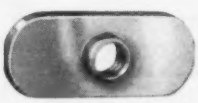


WW NUTS Used where a hermetic seal is required to prevent leakage of air, gas, water or dust on blind locations.



(Patent No. 2,908,310)

RN NUT with pilot and dual-line projections. Ideal in applications where tension is against the weld.



ND NUT Used where a large nut is needed for bridging or joining two sheets or for extra strength.

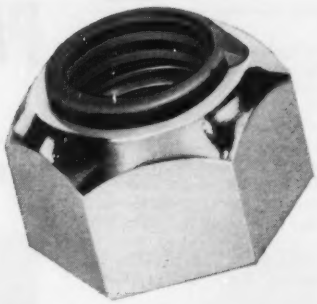
In addition to weld nuts, OHIO stocks a complete line of weld screws—nine different styles for both projection and spot-welding. Send for the complete OHIO catalog.

The OHIO WELD FASTENERS Primary Fastener in Fastener Assemblies

THE OHIO NUT AND BOLT CO.

38 FIRST STREET BEREA, OHIO

Circle F-24 on Page 97



The Finest Quality in a Locknut!

Security Locknuts are the answer for those installations requiring high-locking power, yet ease of removal and reusability. They give improved appearance to a piece of equipment, facilitate repair and cut installation time.

Sizes: From ½" to 4".
Finish: Plain steel or plated.
Type and Material: Security Locknuts can be furnished in various steel analysis.

How the Security Locknut Works: The Security Locknut consists of two parts that work as a single unit. The high-tension spring steel locking insert is elliptical in shape and is a permanent part of the unit. As the nut is wrenched (or applied) on to the bolt, the spring steel insert is forced into the round and grips the bolt with positive tension. The nut will remain in place until removed. It can be removed and replaced any number of times.

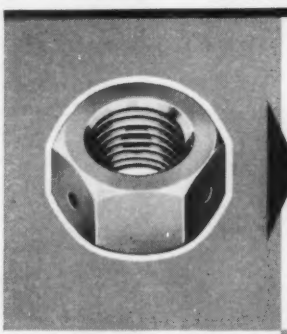
Security

THE NUT YOU CAN'T SHAKE LOOSE

SECURITY LOCKNUT CORPORATION

1800 No. 15th Avenue Melrose Park, Illinois

Circle F-22 on Page 97

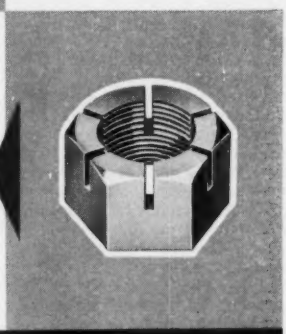


STOLLOCK NUT

- Starts freely on either side by hand or automatic — speeding your assembly time.
- Solid one piece all metal locking action with three indentations — no nut distortion.
- Indentation can be regulated to .001 of an inch.
- Can be made from heat treated high carbon steel for heat treated bolts — or brass or aluminum.

MARSDEN NUT

- Free spinning.
- Locks itself when tightened.
- Reusable.
- Can be made from heat treated carbon steel.
- Millions used in automotive production.



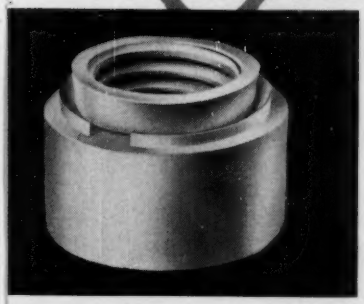
ZL ZIMMER-LIGHTBODY INDUSTRIES INC.

25645 GRAND RIVER AVE.
DETROIT 40, MICHIGAN
PHONE: KE 1-7280

Circle F-23 on Page 97

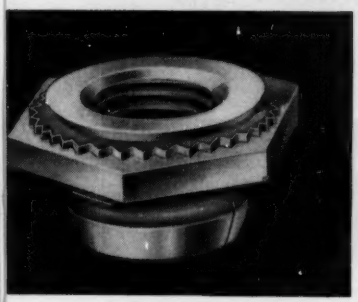
PEM CAPTIVE THREADS for Production Fastening...

THE ORIGINAL SELF-CLINCHING FASTENER



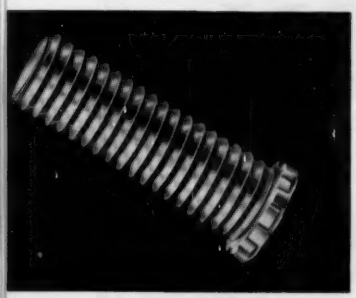
Made in steel, stainless steel, aluminum and Monel. Positively locked into prepared holes by any standard squeezing tool. For metal thicknesses down to .032". Sizes from No. 0 to ¾". Bulletin CL.

SELF-CLINCHING, SELF-LOCKING NUT



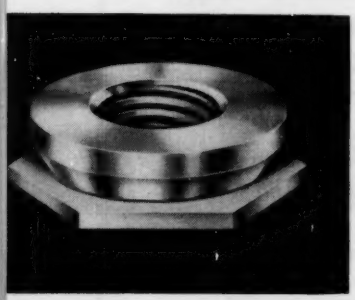
All metal (steel, stainless steel or aluminum) combines 2 functions in single light-weight, low-cost unit for sheet metal fastening. Suitable for installation in sheet thicknesses from .040" and up. Sizes from No. 2 to 10. Bulletin SL.

SELF-CLINCHING CAPTIVE STUD



Steel and stainless steel, designed for quick, easy flush-head installation in panels of cold-rolled steel, brass, copper, aluminum alloys and similar materials. Sizes No. 4 to 5/16". Lengths from ¼" to 1½". Bulletin FH.

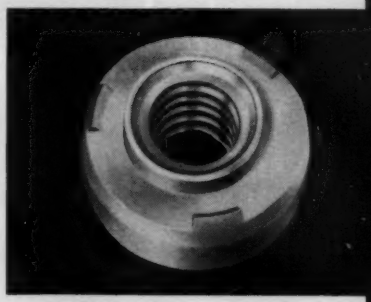
SELF-CLINCHING FLUSH FASTENER



One-piece, stainless steel threaded insert installs in sheet thicknesses from .061" and up with flush mounting area on both sides of sheet. Suitable for materials with Rockwell Hardness of B-70 and less. Sizes No. 2 to ¼". Bulletin FH.

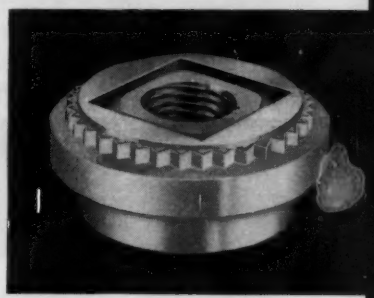
SELF-LOCATING WELD FASTENER

Steel and non-magnetic stainless steel. Nut is projection welded to part with extended shank protecting threads from weld splatter and serving as pilot in assembly. No. 2 to ¼". Bulletin WN.



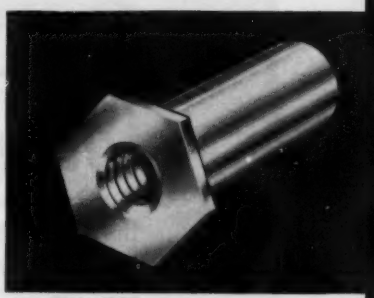
SELF-CLINCHING FLOATING NUT

Carbon steel and stainless steel. Provides rapidly assembled nut anchor in sheet metal and compensates for slight errors (up to 1/32") in alignment of mating holes. Sizes No. 2 to ¼". Suitable for sheet thicknesses from .040" up. Types AS and AC.



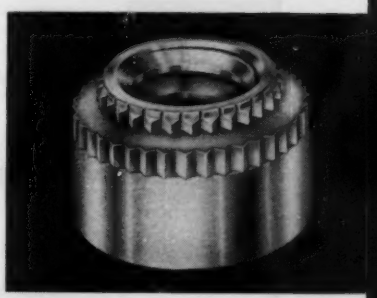
SELF-CLINCHING STAND-OFFS

Made in both blind and threaded-through types in steel, aluminum and stainless steel. Sizes No. 4 and No. 6. Overall lengths from ⅛" to 1 1/16". Suitable for use in sheet thicknesses from .040" and up. Bulletin SO.



SELF-CLINCHING SPLINE FASTENER

For hard metals and brittle materials — magnesium, glass laminates, epoxies, etc. Made in steel and stainless steel. Sizes No. 2 to ⅜". Type KF.

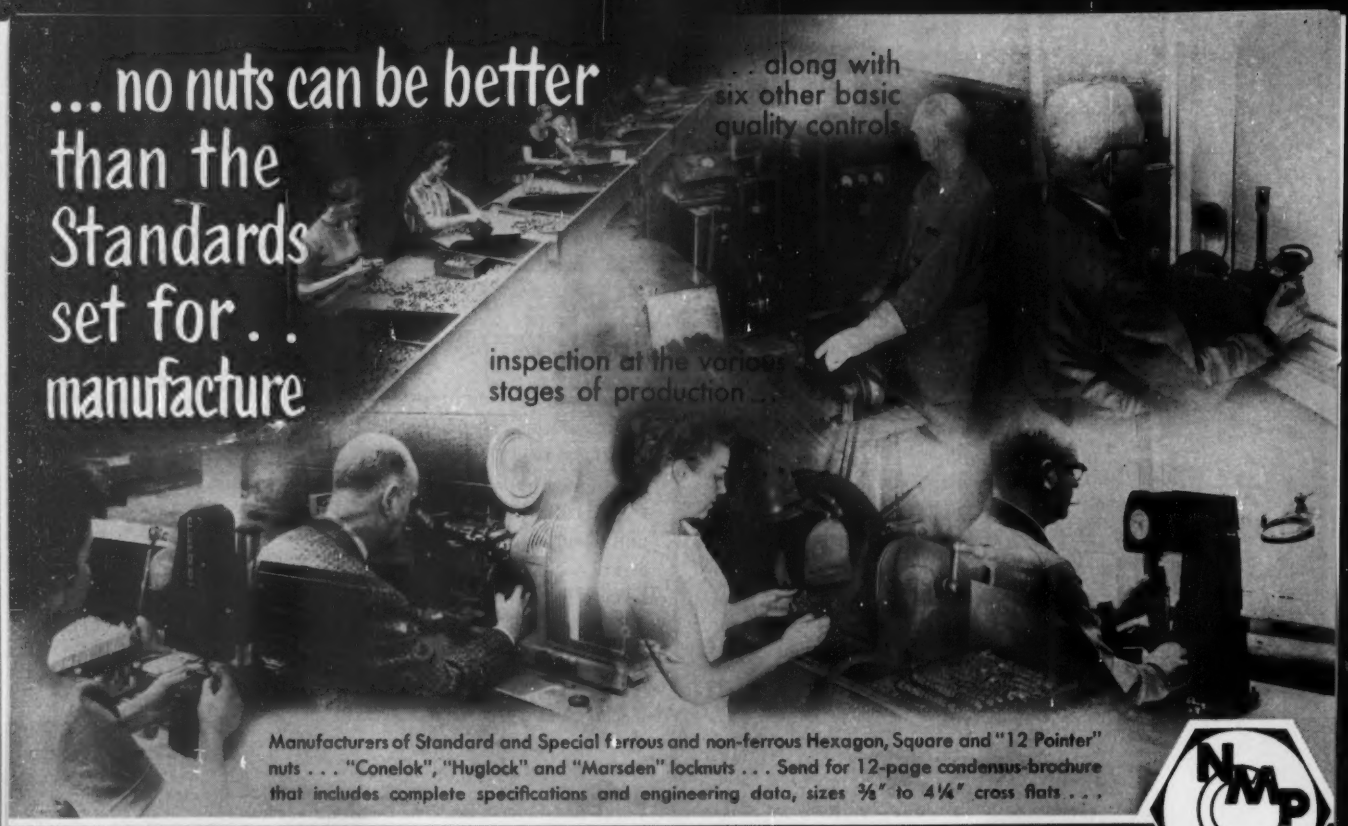


Circle F-20 on Page 97

PENN ENGINEERING & MANUFACTURING CORP.

DOYLESTOWN • PENNSYLVANIA

NEW YORK (BELLE HARBOR, L.I.)—NEPTUNE 4-7103
CINCINNATI—GRANDVIEW 1-9011
CHICAGO (FOREST PARK, ILL.)—FOREST 6-4971
INDIANAPOLIS—CLIFFORD 1-4029
DETROIT—UNIVERSITY 3-5189
TOLEDO—GREENWOOD 4-9563
MILWAUKEE—BLUEMOUND 8-6116
MINNEAPOLIS—GREENWOOD 4-6703
DALLAS—FLEETWOOD 7-5713


... no nuts can be better than the Standards set for . . manufacture
. . along with six other basic quality controls
inspection at the various stages of production . . .

Manufacturers of Standard and Special ferrous and non-ferrous Hexagon, Square and "12 Pointer" nuts . . . "Conelok", "Huglock" and "Marsden" locknuts . . . Send for 12-page condensus-brochure that includes complete specifications and engineering data, sizes ⅜" to 4¼" cross flats . . .

NMP

NATIONAL MACHINE PRODUCTS COMPANY

an SPS company 44250 UTICA ROAD UTICA, MICHIGAN

Circle F-21 on Page 97

ORGANIZATION
for use and reference . . . .

The FASTENERS Book has been carefully organized for your quick and easy use . . . as well as for your continued reference.

Basic Design Data is up front, in a continuous section of some 80 pages.

The Product Directory comes next, organized into these eight sections:

1. INSERTS
2. NUTS (LOCKING & NONLOCKING)
3. PINS
4. QUICK-OPERATING FASTENERS
5. RETAINING RINGS
6. RIVETS (SOLID & TUBULAR)
7. SCREWS, BOLTS & STUDS
8. WASHERS

And, remember! If you want further information on any advertiser's products shown in the Directory, use a Reader Service Card, page 97.

MACHINE DESIGN

A PENTON PUBLICATION CLEVELAND 13, OHIO

COLD PUNCHED

MACHINE SCREW NUTS

- HEXAGON
- SQUARE
- SMALL PATTERN
- STANDARDS
- SPECIAL

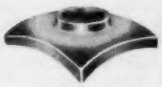
STEEL and ALUMINUM

NEW ENGLAND NUT MFG. CO., INC.
17 VIKING TERRACE • WORCESTER, MASS.

Circle F-26 on Page 97

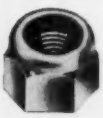
CONDUIT LOCKNUTS — Up to 6"

LOCKNUTS Reversible — One Piece



SPRING-NUTS

J-LOK Reversible with Delrin Insert Pat. Pending

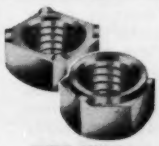


STOP-NUTS

VOLUME-CONTROL & SWITCH MOUNTING NUTS

MACHINE SCREW & FINISHED NUTS

WING NUTS



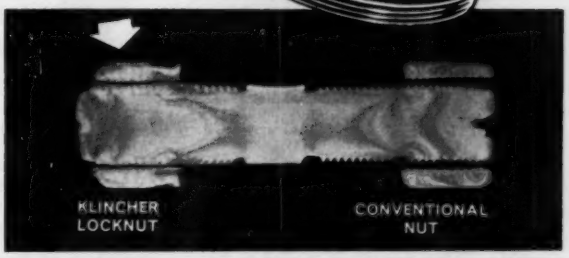
WELD NUTS Square & Hexagon

Available in Stainless Steel, Brass, Aluminum and Steel

JACOBSON NUT MFG. CORP. Kenilworth, New Jersey

Circle F-27 on Page 97

NOTHING KLINCHES LIKE *Klincher* LOCKNUTS



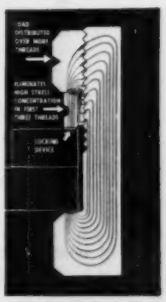
Isochromatic of photoelastic Klincher Locknut model and conventional nut under same load condition showing stresses set up in stud.

Scientific evaluation now proves what smart engineers have always known—nothing Klinches like *Klincher Locknuts.*

Recent photoelastic stress analysis conducted at the University of Minnesota proves that stresses in a *Klincher Locknut* were less than half as great as in a conventional nut under the same load conditions. The stress effect on the stud is one and one-half times greater with a conventional nut.

Thermal expansion up to 1600 degrees Fahrenheit and contraction is compensated for by *Klincher* spring action.

The *Klincher Locknut* locks after the proper torque is applied by compressing the threaded section inside the washer against the bolt, both radially and axially. The high load stress and torsional load are distributed evenly in the main body of the nut. More wrench torque can be applied before exceeding the elasticity in the bolt.



For high temperature fastening, particularly where road shock, high frequency vibration and tensile strength are factors . . . specify *Klincher Locknuts.*

More complete information on *Klincher Locknuts* is available. Write for data and samples, giving size and application.

KLINCHER LOCKNUT CORPORATION
2153 Hillside Avenue • Indianapolis 18, Indiana

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PRODUCT DIRECTORY

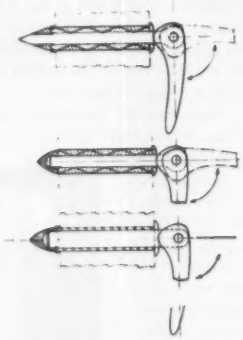
CHAPTER 23

Pin Fasteners

SEVERAL pin devices have been developed primarily for fastening applications. Where loading is mainly in shear and the required clinching force is small or negligible, they can often be employed to cost advantage. Other possibilities include multipurpose functions as a locking fastener and a hinge, shear pin, locating surface, retaining shoulder, or bearing face.

Adjusto-Fit Pin

Form: Single-unit, all-metal pin with adjustable diameter-body. Assembly consists of pin shank with camming handle on one end, conical bushing retainer on other end, and an expandable-bushing assembly. When pressure is applied at the ends of bushing by camming handle, OD of bushing expands and bears against hole wall and ID of bushing contracts and grips pin shank. This two-way action locks the pin tightly in place.



Design Features: Provides interference-fit pin with quick-release features. Can be used in holes as much as 0.060 in. oversize. Will withstand comparatively large tension loads.

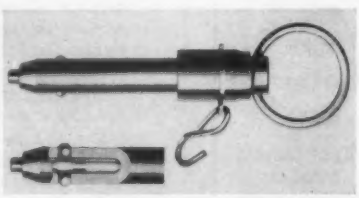
Materials: Steel, corrosion-resistant steel, stainless steel, aluminum, and high-strength steel.

Sizes: 5/16 in. pin diameters up. Various lengths.

Source: Adjustable Bushing Co., North Hollywood, Calif.

Ball-Lok Double-Acting Pin

Form: Double-acting type, quick-release locking pin fastener assembly containing spring action plunger-and-ball locking mechanism. In locked position balls extend beyond the diameter of pin shank, providing a positive lock. Plunger has two sets of cavities so locking balls will recede flush with pin diameter when plunger moves in either direction. Pressing on extended plunger tip at either end of pin releases the locking balls for insertion or withdrawal of pin.



Design Features: Requires no special assembly tools. Provides "drive-in drive-out" features to permit forcible release of the pin in applications where misaligned holes or overloads tend to bind the pin. An intentional blow on either extended tip moves the pin for forcible insertion or withdrawal. Pins are designed primarily for shear loading although they will withstand considerable tensile force. Provides a dependable, quick-release fastener.

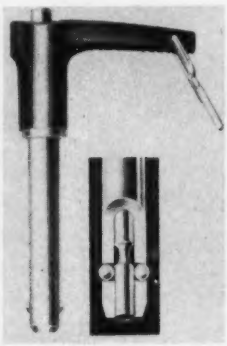
Materials: Heat-treated chrome-moly steel or corrosion-resistant steel.

Sizes: 1/4 to 1 in. pin diameters. Head styles include L, T, and ring handle designs.

Source: Avdel, Inc., Burbank, Calif.
(See Ad, Page 148)

Ball-Lok Single-Acting Pin

Form: Quick-release locking pin fastener assembly containing spring loaded plunger-and-ball locking mechanism. In locked position balls extend beyond the diameter of the pin shank to provide a positive lock. For insertion or withdrawal of pin, button at head of pin is pushed, causing plunger to move. Balls fall into cavities in the plunger and remain flush with pin diameter until button is released. When button is released balls extend to locking position.



Design Features: Requires push or pull to insert or remove. No special tools required. Facilitates assembly and servicing operations as well as providing for quick emergency release. Pins are designed primarily for shear loading although they will withstand considerable tensile force. Holes are reamed to nominal pin diameters to give free fit. Provides dependable quick-release fastener.

Materials: Heat treated chrome-moly steel.

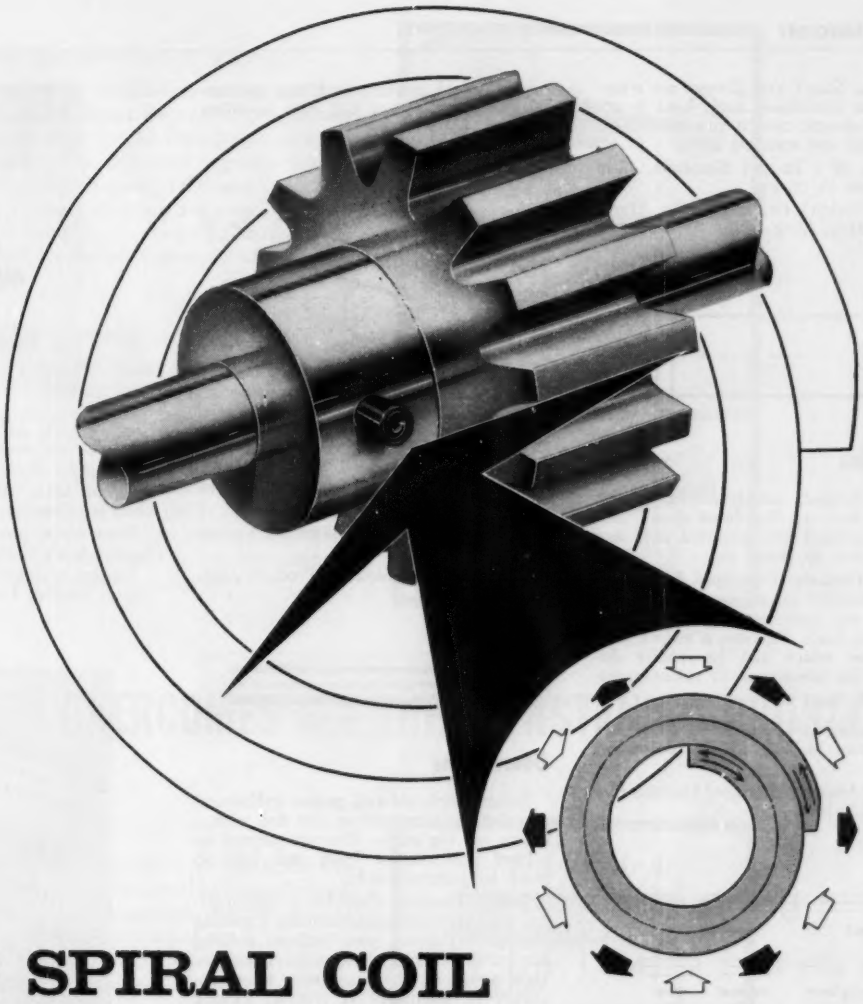
Sizes: 1/4 to 1 in. pin diameters. Grip lengths from 0.2 in. up. Head styles include L, T, buttonhead, cam-lever action, and ring types.

Source: Avdel Inc., Burbank, Calif.
(See Ad, Page 148)

BB-Pins

Form: Single-action type, quick-release locking-pin assembly containing positive-locking plunger and ball locking mechanism. In locked position balls protrude beyond diameter of pin shank to provide positive lock. When plunger is moved by button at end of pin, balls are released to permit movement of pin in hole. Plunger is returned to locked position by spring action of rubber core at end of pin.

Design Features: Reusable. Provides positive attachment with easy removal. Can be used for tension and shear-load applications. Recessed head protects release button from accidental release. Sealed mechanism prevents jamming and freezing. Requires no special tools for assembly or disassembly.



THE SPIRAL COIL

makes SPIROL a true spring PIN

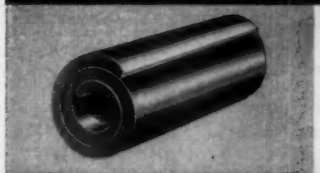
SPIROL PIN is a spirally coiled metal strip that acts like a true spring. When the pin is compressed into a hole, the radial tension is distributed *uniformly* throughout the spiral coils. There is no concentration of stress along a fragile "hinge line". This real coil-spring action permits wider plus-*and*-minus hole tolerances . . . eliminates precision reaming . . . works successfully with *low-cost* non-heat-treated metals. SPIROL's greater resilience increases shear strength, shock and vibration resistance.

FREE! *Write for literature on Spirol Pins.*

®SPIROL *the true spring* **PIN**

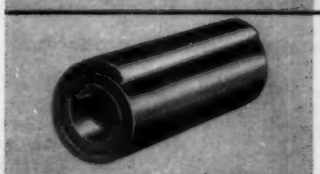
C. E. M. COMPANY, INC. • 63 SCHOOL ST. • DANIELSON, CONN.

SPIROL offers the widest range of flexibility, tension, and strength . . .



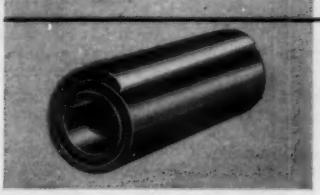
HEAVY DUTY

For applications where shear and shock loads are extremely severe, Spirol pin's spring action withstands high stress.



MEDIUM DUTY

Flexibility enables medium duty pins to absorb severe vibration. Have adequate shear strength for majority of applications.



LIGHT DUTY

Recommended for use in soft and brittle materials where the allowable bearing loads are low.

Materials: Shank and plunger are stainless steel or chromium steel; head is anodized aluminum; core is silicone rubber; locking balls are stainless steel.

Sizes: ¼ to 1 in. pin diameters. Grip lengths from ½ in. up.

Source: Waldick Engineering Co., Huntington Station, Long Island, N. Y.

Clevis Pins

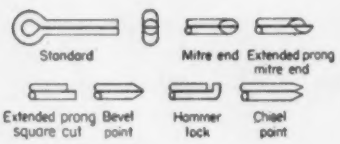
Form: Headed, unthreaded pin with cotter-pin hole at chamfered shank end. Pin is assembled into prepared hole and held in place by cotter pin.

Design Features: Developed for fastening knuckle-joint assemblies. Used to connect two rod members under tensile or compressive loads. Provides a mobile joint construction which can be readily disconnected for adjustment or maintenance.

Material: Steel.

Sizes: 3/16 to 1 in. nominal diameters. Lengths from 19/32 to 2⅝ in., depending on size.

Source: *American Standard Machine Pins* —ASA B5.20-1958.



Cotter Pins

Form: One-piece, split cylindrical metal pin with loop formed at one end. Pin is inserted in hole and split ends are bent over to lock pin in place.

Design Features: Provides a retaining shoulder to hold parts in place on threaded or unthreaded stud or rod members. Used to lock clevis pins, castle nuts, or slotted nuts in position. Diameter of inside loop is approximately the same as pin diameter.

Materials: Mild steel, brass, bronze, stainless steel, and aluminum.

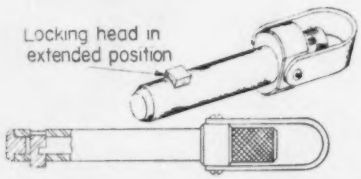
Sizes: 0.031 to 0.750-in. nominal pin diameters. Body styles include square, mitre, prong, bevel, hammer lock, and chisel point end shapes.

Source: American Standard *Machine Pins*—ASA B5.20-1958.

(See Ad, Page 148)

Davis Loc-Pin

Form: Single-action type, quick-release, locking pin assembly containing cam-actuated locking-head mechanism. In locked position, locking head protrudes beyond diameter of pin shaft to provide positive lock. Locking head is moved to lock or unlock position by lifting up handle and rotating it a half turn in either direction.

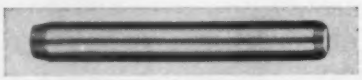


Design Features: Provides positive attachment with easy removal. No special tools required for assembly or disassembly. Designed primarily for shear loads but will withstand considerable tension loads. Pin may be force driven from either end.

Material: Alloy steel.

Sizes: ¼ to 1 in. pin diameters. Various grip lengths.

Source: Davis Aircraft Products Inc., New York, N. Y.



Dowel Pins

Form: Hardened-and-ground cylindrical pin that is chamfered on one end with a crown on the other. Pins are pressed or tapped into reamed holes and held in place by interference fit.

Design Features: Provides a high-quality, high-strength precision-made fastening element. Primary uses include holding laminated sections together in spaced or tight assembly; fastening parts where accuracy of alignment is critical; locking components on shafts in the form of a transverse pin key, where a secure, high-strength joint with minimum stress concentration under severe torque loads is desired. Can also be used for combination functions as a locking fastener and hinge, wrist pin, or small stub shaft in moving parts.

Material: Heat-treated alloy steel.

Sizes: ⅛ to ⅞ in. nominal diameters. Lengths from ½ to 5½ in., depending on size. Body styles include standard (0.0002 in. oversize) and oversize (0.001 in. oversize).

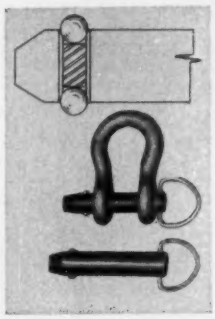
Source: *American Standard Machine Pins* —ASA B5.20-1958. Photo, courtesy John Gillen Co. Inc., Cicero, Ill.

(See Ad, Page 147)

Eco-Pins

Form: Solid-shank, quick release locking pin assembly containing floating rubber core and large locking balls. Locking balls project from surface of pin until sufficient force is applied in assembly or removal to depress balls against spring action of rubber, releasing pin for movement.

Design Features: Reusable. Provides low-cost positive attachment with easy removal. Can be used as clevis, anchor-shackle, safety-lock, or shear-load pins. Locking mechanism resists vibration.

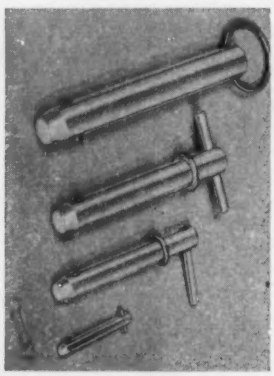


Locking balls will hold pin in holes up to 20 per cent oversize.

Materials: Shank is stainless steel, plated steel, or brass. Balls are stainless steel. Core is silicone rubber composition.

Sizes: ¼-in. pin diameters and up. Grip lengths from ¼-in. up.

Source: Waldick Engineering Co., Huntington Station, Long Island, N. Y.



Faspins

Form: Solid shank quick-release locking pin assembly containing spring-loaded locking ball. Ball projects from surface of pin until sufficient force is applied in assembly or removal to depress it against spring, releasing pin for movement.

Design Features: Reusable. Provides positive attachment with easy removal. Requires no assembly tools. Can be used as shear, lock, clevis, or hinge pin. Solid pin shank develops shear strengths varying from 2420 (3/16 in.) to 70,190 lb (1 in.).

Materials: C 1144 steel, 303 Stainless steel, and others.

Sizes: 3/16 to 3 in. pin diameters. Grip lengths from 0.3 to 12 in. Pin styles include T or L-type handle, or grip rings. Body types include one or two ball designs.

Source: Aerofast, Wheaton, Ill.

Groove Pins

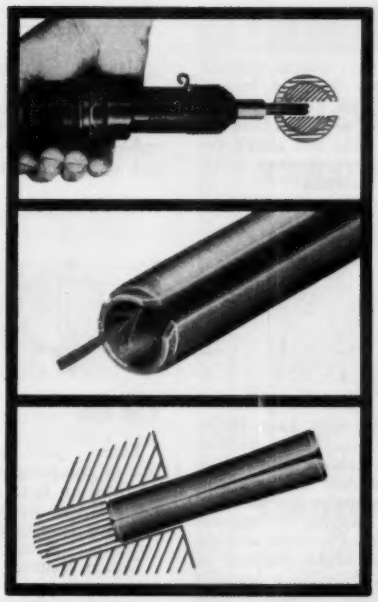
Form: Types A, B, C, D, E, and F American Standard grooved pins. Type A has full length tapered grooves; Type B has tapered grooves over only half of its length; Type C has full-length parallel

Rollpin won't mushroom or telescope

There are no installation or removal problems with Rollpins. Because of their column strength they can be readily driven with a hammer, removed with a punch without bending or collapsing. Of course production line tooling such as an arbor press, a pneumatic hammer . . . even a hand riveter . . . is ideal for Rollpin insertion.

Rollpin won't damage or enlarge hole

With smoothly chamfered ends providing an easy lead-in, Rollpin is compressed into complete conformity with the shape of the hole. The exclusive, v-shaped, coped corner design eliminates possibility of damage to the hole walls. They prevent any possible scoring action as the pin is driven and insures uniform insertion and removal characteristics. The benefit to you: the same pin can be reused in the same hole.



ONLY ROLLPIN OVERCOMES ALL THESE FASTENING PROBLEMS!

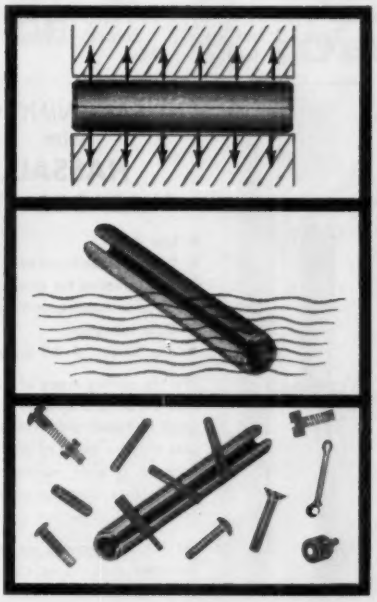
Rollpin exerts EVEN pressure

In some fasteners, only a portion of the fastener shaft does the actual holding. Rollpin, however, exerts a uniform pressure around the entire inside surface of the hole—giving you maximum holding power and superior resistance to vibration.

Split tubular construction assures uniformity of heat treatment that is difficult to obtain with spiral types of pins; there is an even plating "throw" inside the pin as well as outside for superior corrosion protection.

ONE TYPE of Rollpin does EVERY TYPE of job

Versatile Rollpins will replace at least 12 different types of fasteners. Every Rollpin can be hopper-fed, can be installed with a single operation. They are available, from stock, in a wide range of lengths and in diameters from 1/16" to 1/2". Manufactured from carbon or corrosion resistant steels and beryllium copper.



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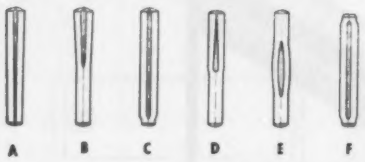
Circle F-31 on Page 97

grooves; Type D has reverse tapered grooves; Type E has centrally located oval grooves; and Type F has parallel grooves with symmetrical form. Pins are forced into prepared hole and elastic deformation of the grooves develops radial forces to lock pin in position.



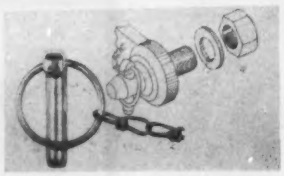
Design Features: Provides force fit in hole. May be reused many times without appreciably affecting holding action. Can be installed with hammer or press and is adaptable to mass-production methods. Eliminates need for tapping or reaming of taper or sized holes. Pin locks securely in drilled hole and is highly resistant to shock and vibration. Provides a low-cost headless locking fastener. Type A is basic pin form for general purpose service. Type B speeds assembly because ungrooved portion acts as a pilot. It is used where holding power is not critical. Type C is recommended for severe shock and vibration service where maximum holding power is required. Type D is particularly suited to blind-hole applications because of reverse groove construction. Type E is especially suited for quick removal and replacement. Type F is essentially the same as Type C but has pilots on both ends for hopper feeding.

Material: Cold-drawn steel.

Sizes: 3/64 to ½ in. nominal pin diameters. Lengths from ⅛ to 4½ in.

Source: *American Standard Machine Pins* —ASA B5.20-1958.

(See Ads, Pages 147, 148)



Klik-Pin

Form: Quick-release locking pin assembly consisting of forged pin with ring mounted on head end. Pin is inserted in prepared hole in shaft or similar member, and ring is snapped over end of shaft to lock pin in place.

Design Features: Provides positive pin attachment with easy removal. Solid pin construction develops full shear strength of pin material. Rings are wound so that direction of spiral keeps them firmly closed when folded down against the pin. Requires no special assembly tools. Design of mounting holes for ends of rings assures good pivotal bearing and assists snap action of rings.

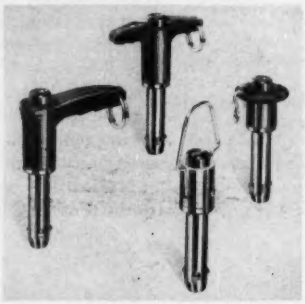
Materials: Pin is heat-treated high-carbon steel; ring is tempered steel.

Sizes: 1/4 and 7/16-in. pin diameters; two snap ring sizes.

Source: Danuser Machine Co., Fulton, Mo.

Lockwell Pin

Form: Single-action type, quick-release, locking-pin assembly containing spring action plunger-and-ball locking mechanism. Pin is assembled in suitable prepared hole. In locked position, four uniformly spaced balls protrude beyond diameter of pin shank to provide positive lock. When plunger is moved by depressing button at end of pin, balls are released to allow insertion or removal of pin.



Design Features: Requires no special tools for assembly or disassembly. Pins are fastened to structure by cable lanyard to prevent loss when disassembled. Steel shoulder construction and four-ball locking element give high tension capability. Continues to be operational if handle is broken. Provides reliable quick-release fastener where frequent assembly and disassembly are required.

Materials: Shank and spindle are alloy steel or 17-4 PH corrosion-resistant steel; balls are corrosion-resistant steel; handle is mild steel, corrosion-resistant steel, or aluminum.

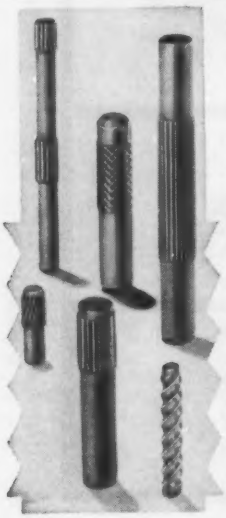
Sizes: 3/16 to 1 in. pin diameters. Various grip lengths. Handle styles include wire-loop, button, L, and T designs.

Source: The Hartwell Corp., Los Angeles, Calif.

Pawl-Loc

Form: Single-action type, quick-release locking pin assembly containing spring-action plunger and pin-type locking mechanism. In normal locked position, locking element protrudes beyond diameter of pin shank. When button at end of pin is depressed, movement of plunger retracts locking element to permit insertion or removal of pin shank in prepared hole.

Design Features: Provides reliable quick-release fastener where frequent assembly and disassembly are required. Requires no



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special tools for insertion or removal. Operation of locking mechanism is positively controlled, preventing accidental release and freezing of locking element. Pin-type locking element is loaded under line contact, minimizing danger of brinelling of parts.

Materials: Pin and locking element are steel or corrosion resistant steel; head is aluminum, steel, or corrosion resistant steel.

Sizes: ¼ to 1 in. pin diameters. Grip lengths from 0.1 to 9.9 in. Head styles include L-handle, T-handle, and button head.

Source: Deutsch Fastener Corp., Los Angeles, Calif.

Spirol Pin

Form: Hollow cylindrical pin made of spiral-wound metal strip. When pin is driven into prepared hole of smaller diameter, spring action of coils locks it in place.

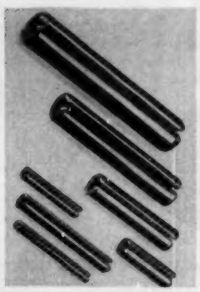
Design Features: Reusable. Strength and locking properties of pin can be readily changed by varying coil construction. Eliminates need for precision drilling and reaming of holes. Can be used in soft or brittle materials without damaging holes or cracking material. Provides lightweight, headless fastener with high resistance to shock and vibration loads.

Materials: 1070 carbon steel, and 302 and 410 stainless steel.

Sizes: 1/32 to 3/4-in. nominal pin diameters. Lengths from 1/8 to 4 in.

Source: C.E.M. Co. Inc., Danielson, Conn.

(See Ad, Page 143)



Spring Pin

Form: Slotted, hollow cylindrical pin. When pin, which is made oversize, is driven into standard drilled holes, spring action of compressed pin wall locks it in place.

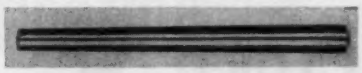
Design Features: Reusable. Fits flush. Resists loosening effect of vibration and wear. Eliminates need for reaming or tapering of holes. Can be inserted by hand or machine. Pin is lighter than solid mild carbon steel pin, yet has greater shear strength. Hollow construction permits "doubling-up" of pins for greater strength. Provides low-cost, lightweight, headless fastener with high shear strength.

Materials: Carbon and Corrosion-resistant steel, and beryllium copper.

Sizes: 0.062 to ½-in. nominal pin diameters. Lengths from 3/16 to 5½ in.

Source: Produced by several manufacturers. Photo, courtesy Elastic Stop Nut Corp. of America.

(See Ads, Pages 145,147)



Taper Pins

Form: Cylindrical metal pin with tapered body. Pin is driven into sized hole until fully seated to provide a tight fit.

Design Features: Provides a simple, reliable fastener element. Taper of pin aids hole alignment in assembly and also facilitates pin removal.. Widely used for light-duty service in the attachment of wheels, levers, and similar components to shafts.

Materials: Mild and alloy steel, stainless steel, and brass.

Sizes: No. 7/0 (0.0625 in. large end) to No. 14 (1.523 in. large end) nominal sizes. Lengths from ⅜ to 6 in. Pin types include commercial (without a concavity tolerance) and precision (with a concavity tolerance).

Source: *American Standard Machine Pins* —ASA B5.20-1958. Photo, courtesy John Gillen Co. Inc., Cicero, Ill.

(See Ad, Page 147)

WE-Pins

Form: Solid-shank, quick-release locking pin assembly containing rubber core and lock button. Lock button projects from surface of pin until sufficient force is applied in assembly or removal to depress button against spring action of rubber, releasing pin for movement.

Design Features: Reusable. Provides positive attachment with easy removal. Pull-out loads range from 10 to 25 lb, depending on pin size, to prevent accidental release due to vibration. Solid pin shank develops high shear strength varying from 3600 (1/4-in.) to 58,000 lb (1 in.). Can be used as shear, lock, hinge or clevis pin. Locking mechanism resists vibration, corrosion and temperature variations.

Materials: Pin is stainless steel or chrome-moly steel. Core is silicone rubber composition.

Sizes: 1/4 to 1-in. pin diameters. Grip lengths from 1/2 to 4 in. Pin styles include several pull-grip designs as well as dual lock-buttons in the larger diameters.

Source: Waldick Engineering Co., Huntington Station, L.I., N.Y.

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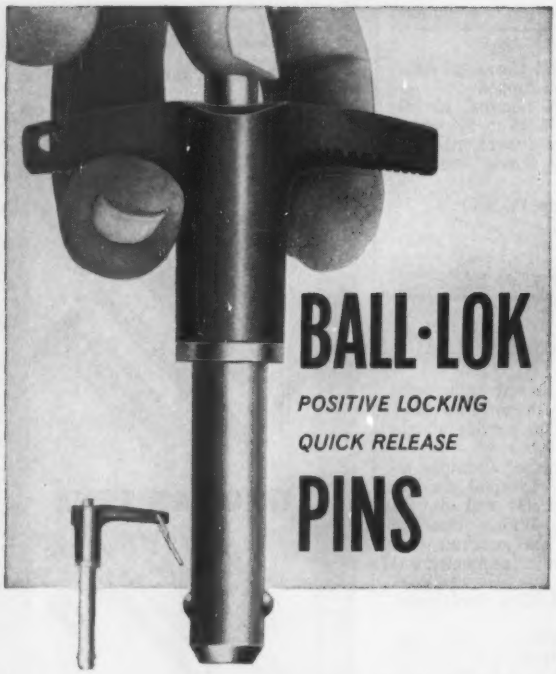

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QUICK RELEASE

PINS

FAST...SAFE...DEPENDABLE

Available in both single acting and double acting styles.

The ideal fastener for applications where parts or assemblies are frequently assembled or disassembled for service or replacement. Also BALL-LOK PINS are widely used as a safety fastener to prevent accidental or premature release of movable assemblies.

For every design requirement where a pin fastener must be easy to insert...quick to withdraw, yet provide positive safety BALL-LOK single acting pins serve best. Five head styles adapt to all design requirements. Pins range from 3/16" (#10) to 1" diameter.

POSITIVE RELEASE UNDER "OVERLOAD" OR "BOUND" CONDITIONS

Double acting BALL-LOK Quick Release Pins combine rugged strength with instant insertion, easy withdrawal and self safetying. In cases where ordinary fasteners may bind in misaligned holes or under heavy loads the added "drive-in" "drive-out" spindle permits forcible release of the pin. Double acting pins are available in "Ring," "T" and "L" head styles. Use the experienced technical knowledge of our engineering staff to help solve your quick release fastener problems.

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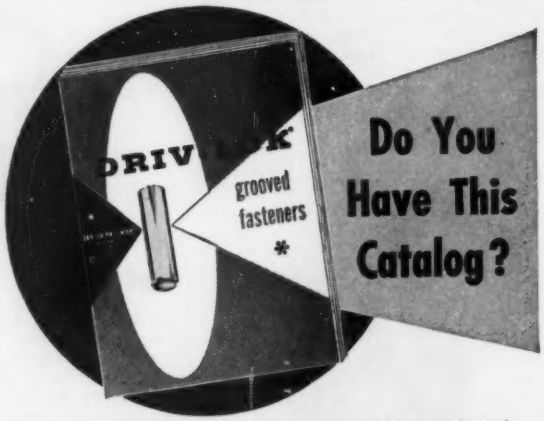

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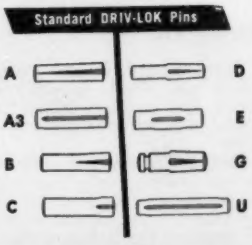
Write for your copy of the DRIV-LOK catalog today. Contains factual data in concise, easy to use form. Illustrated with typical applications that may help solve a fastening problem for you. Sent without obligation, of course.



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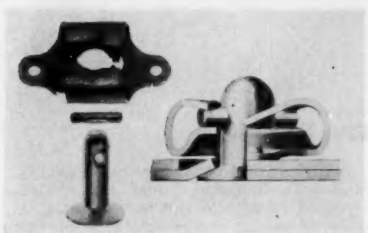
Circle F-34 on Page 97

CHAPTER
24
Quick-Operating Fasteners

A NUMBER of quick-operating devices have been developed to speed and simplify manual assembly and disassembly of panels, access doors, and other demountable parts. In form, these fasteners range from simple latches and catches to elaborate quick-opening and special purpose types based mainly on aircraft requirements. Comparable functions are also offered in certain applications by the various quick-release pins (Chapter 23).

Basic commercial types of quick-operating fasteners in three categories are covered here: 1. Rotary-operated types. 2. Lever-actuated types. 3. Slide-action types. Rotary-operated types depend on a turning or rotary motion, imparted to some actuating member, for opening or closing. The various multiple and partial-turn panel fasteners and latches are typical. Actuating members take the form of a knob, handle, screw, nut, or bolt. Lever-actuated types are operated through a release or locking-lever arrangement. Draw-bolt, catch, cam, and toggle-latch types fall in this group which contains both direct-action and spring-loaded latches. Slide-action types are operated by sliding one member over or through another.

Rotary Operated Types



Airloc

Form: Three-piece, quarter-turn fastener: Receptacle, stud, and pin. Pin is rotated past indentations on upper wing surface of receptacle and snaps into locked position. Further turning is prevented by stops on wings of receptacle.

Design Features: In unlocked position, projection on upper wing of receptacle ejects stud into visible position.

Materials: Receptacle, stud, and pin are steel; grommets are aluminum.

Sizes: Rivet spacing, ½, ¾, 1, and 1⅜ in. Stud diameters, ⅛, 11/64, 17/64, and 5/16-in. Range of panel thickness, 0.30 to 1.50 in. Stud head styles include flush and round with slotted or Phillips recess, and wing type. Modified receptacle designs.

Source: Monadnock Mills, Subsidiary of United-Carr Fastener Corp., San Leandro, Calif.

Cam-Bolt

Form: Single-unit assembly: Bolt, castle nut, flat spring, stop washer, and a cotter pin. To install, hole is drilled in one flange and other flange is slotted. T-headed bolt is slipped through hole and slot, then spring and washer placed over other end. Nut is turned on to the desired preload, then locked in place with cotter pin.

Design Features: Designed specifically for pressurized missile and engine containers. After installation, joint can be released by ¼ turn of the T-headed bolt.

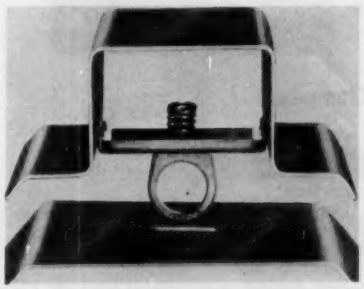
To reassemble, slip slot over bolt and give it ¼ turn again, causing cam surfaces on underside of bolt to draw up joint. Since nut remains locked with cotter pin, the same original preload is kept on the joint.

Material: Steel.

Sizes: ½ and ¾-in. diam. bolt.

Source: Simmons Fastener Corp., Albany, N. Y.

(See Ad, Page 163)



Camloc KM

Form: One-piece, quarter-turn fastener: Coiled spring wrapped around stud with ring-handle which passes through slot in bracket and mating panel. Spring tension holds panels firmly when handle is depressed and rotated one-quarter turn.

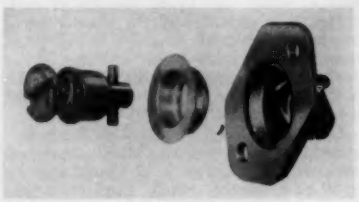
Design Features: Installs quickly without riveting or spot welding.

Materials: Steel.

Sizes: Clearance slot, 9/32 by 1 5/16 in. and 11/32 by 1½ in. Overall length 2 and 2¾ in. Rigid or fold down handles. Standard and heavy-duty types.

Source: Camloc Fastener Corp., Paramus, N. J.

(See Ad, Page 168)



Camloc Quick-Release

Form: Two-piece, quarter-turn fastener: Receptacle and spring-loaded stud assem-

bly. Receptacle has long cam surface, positive stop, and detent for possible locking as stud is turned one-quarter turn.

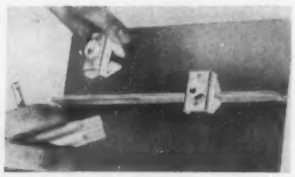
Design Features: In released position, stud is ejected by spring for easy detection. Single stud can be removed without disturbing adjacent studs. Grommets in heavier series prevent panel abrasion. Cam surface provides uniform locking torque.

Materials: Receptacles, silicon bronze, aluminum, and corrosion-resistant steel; studs, carbon and corrosion-resistant steel.

Sizes: Rivet spacing, ¾, 1, and 1⅜ in. Stud diameter, ¼ in. Stud head styles include slotted, winged, knurled, and Phillips recess. Receptacle sealing cup. Lanyard type stud assembly. Modified receptacle designs. Miniature version for small subassemblies and light-panel applications has ultimate tension shear rating of 150 lb and reduced-size receptacle with ½ in. rivet spacing.

Source: Camloc Fastener Corp., Paramus, N. J.

(See Ad, Page 168)



Clamp-Lock

Form: Single-unit fastener assembly: Two clamping jaws are placed over joint, and camming hex is turned ½ turn to close jaws.

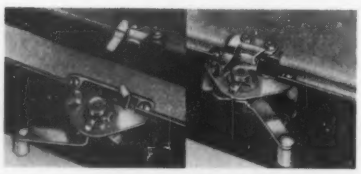
Design Features: For flanged panel enclosures. Reusable, it has a closing pressure of 400 lb and a strength of 700 lb.

Material: Steel.

Size: Surface dimension, 1 1/16 by 1⅝ in. Pull-up distance, 3/16 in.

Source: Simmons Fastener Corp., Albany, N. Y.

(See Ad, Page 163)



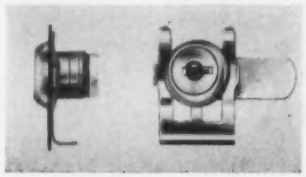
Combination Latch Control

Form: Two-piece latch assembly: Lock unit, which contains an integral switch, and a strike. To close, handle of lock assembly is moved about a quarter turn, camming the strike into the locked position. A projecting arm on the strike contacts a spring-loaded stop, to close the electrical switch. Switch is open when the door is open.

Design Features: Provides an easily operated, positive-locking latch combined with an electrical switch which can be used as a master switch. Used on appliances, so that the machine cannot be started while door is open.

Materials: Steel, and standard electrical construction materials.

Source: Amerock Corp., Rockford, Ill.



Corbin Cabinet Lock

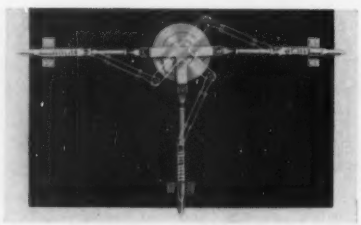
Form: Three-piece lock assembly: Clip lock inserts in hole in door or panel, tension lock clip slips over grooves in lock to hold in place, and locking bolt is inserted in clip lock to complete assembly. Actuated with key.

Design Features: Provides quarter-turn, quick-operated lock for cabinets and enclosures. Key removable in locked or unlocked position.

Material: Steel.

Sizes: For panels 18, 20, or 22 gage sheet metal.

Source: Corbin Cabinet Lock Div., The American Hardware Corp., New Britain, Conn.



Door Bolt

Form: Single-unit latch assemly: Bellcrank, three bolt mechanisms, and mounting plate with handle. Handle turn of approximately 60 deg. opens latch by retracting three bolts. Each bolt is spring loaded in the open direction, handle is spring loaded in the closed direction to hold assembly in either position.

Design Features: For use on doors or panels that must be secured at more than one point. Of particular use on doors which must be closed with positive seal. Individual bolt lengths are adjustable by turnbuckle arrangement for total of ¾ in. to compensate for cabinet variations. Can be used with just two bolts, or with X or Y bellcrank. Flush outside mounting.

Materials: Escutcheons and drive tubes, aluminum, steel, or stainless steel; mechanism and bolts, steel; handles, aluminum alloy.

Size: ⅜-in. diam. bolts, ¾-in. throw. Approximately 1-in. back clearance required. Various bolt lengths.

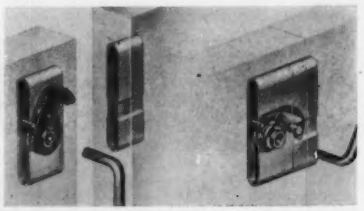
Source: Adams-Rite Mfg. Co. Inc., Glendale, Calif.

Dual-Lock

Form: Two-piece, partial-turn cam latch: Lock mechanism and pin striker. Draw-to locking action is provided by off-center cam which actuates latch hook. Full-open and closed positions are obtained by trigger mechanism operated through projections on cam. Trigger is positioned by female engaging pin.

Design Features: Positive locking is assured by double-acting mechanism. High-load capacity. Operated with Allen wrench.

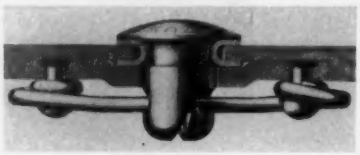
Materials: Alloy steel.



Sizes: Envelope for lock mechanisms, 3½ by 3 11/16 by ⅝ in. Various strike sizes. Design options include flush or surface mounting types.

Source: Simmons Fastener Corp., Albany, N. Y.

(See Ad, Page 163)



Dzus Spiral Cam

Form: Quarter-turn fastener: Stud with spiral cam and mating-spring member. Turning stud a quarter-turn causes spiral cam to engage wire element, compressing spring and seating stud in locked position.

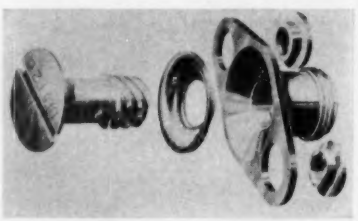
Design Features: In locked position, assembly resists loosening by vibration, yet is quickly opened by a small coin, washer, screwdriver, or special key.

Materials: Studs, heat-treated steel; springs, steel; grommets, aluminum; receptacles, steel.

Sizes: Stud diameters, 3/16 to 7/16 in. Stud lengths, 0.2 to 2.5 in.

Design Options: Variations include multiple-receptacle design (⅜ in. increments) with spring-loaded studs; heavy-duty enclosed receptacle; spring-loaded wing-head type for high-tension locking action; and special spring-member and grommet constructions. Standard head styles include oval, flush, and hex with slotted recess, and wing type.

Source: Dzus Fastener Co. Inc., West Islip, N. Y.



Dzus Universal

Form: Two-piece, partial-turn fastener: Stud with four-lead thread and slotted, threaded receptacle. A wire spring is wrapped around the receptacle to provide locking action. Stud is rotated 270 deg in receptacle to lock assembly. Grommet holds stud captive.

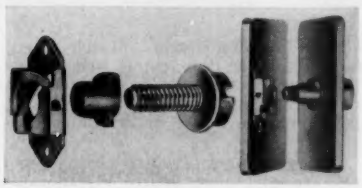
Design Features: Primarily for use in high tensile and shear applications. Resists vibration.

Materials: Receptacle, aluminum alloy; stud and spacer, steel; grommet, aluminum.

Sizes: Stud diameter, 3/16, ¼, and 5/16 in. Rivet spacing ¾ and 1 in. Range of panel thickness, 0 to 1.0 in.

Design Options: Stud head styles include oval, flush, hex, wing, and socket. Modified receptacle and stud-shank designs.

Source: Dzus Fastener Co. Inc., West Islip, N. Y.



Esna Quick Disconnect

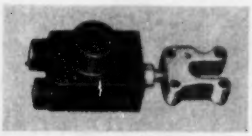
Form: Two-piece, quarter-turn fastener: Receptacle and internally threaded nut. A standard screw inserted in mating panel is threaded into nut. Quarter-turn of screw then locks nut in receptacle.

Design Features: Provides rapid connect or disconnect. Screw and nut assembly permits adjustable tightening of panels.

Materials: Receptacle and latch nut are carbon steel.

Sizes: Rivet spacing, 7/8 in. Nut has ¼-20 coarse thread, class 3B.

Source: Elastic Stop Nut Corp. of America, Union, N. J.



Hartwell Rotary Latches

Form: Two-piece, partial-turn latch: Rotary cam-hook assembly and eye-bolt. Eye-bolt is engaged in the cam-hook assembly and half turn of rotary cam engages eye.

Design Features: Axial adjustment of 0.30 in. is provided by eye-bolt. Indicator signifies latched or unlatched condition. Positive locking. Eye-bolt shank is shear pin between mating surfaces. Axial take-up is provided.

Materials: Housing and bottom plate, aluminum; other parts, steel.

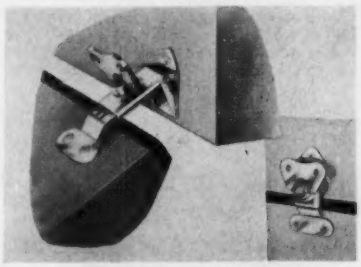
Sizes: Width, 1.35 to 1.38 in.; thickness, 0.99 to 1.56 in.; length, 2.15 to 2.35 in., excluding eye-bolt. Various eye-bolt configurations. Actuator styles include ¼-square drive and remote types. Flush and skin-mounting designs.

Source: The Hartwell Corp., Los Angeles, Calif.

Hinge-Lock

Form: One-piece, half-turn latch: Assembly with hinge-mounted flange. Strap end of assembly is permanently fastened. Half turn of nut draws panels together.

Design Features: Locked fastener lies flat against panel. Designed primarily for cover applications. Positive lock without springs. In released position, panels can be rotated about hinge joints for opening.

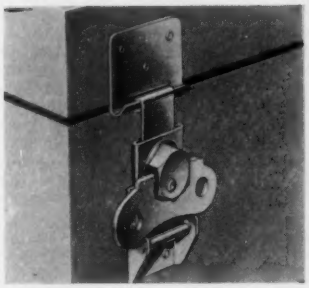


Materials: Alloy steel.

Sizes: Envelopes are 5/8 by 1½ by 2 7/16 in. and 23/32 by 2¾ by 4⅜ in. Actuating member styles include wing, bolt, and screw. Light and medium duty designs.

Source: Simmons Fastener Corp., Albany, N. Y.

(See Ad, Page 163)



Link-Lock

Form: Two-piece, partial-turn latch: Striker plate and hinged locking unit. Hooked strap is engaged in striker and partial turn of nut pulls panels together and locks.

Design Features: Pull-down pressure from 90 to 1500 lb; tension load capacities from 300 to 4000 lb.

Materials: Alloy steel.

Sizes: Envelopes are 5/8 by 1½ by 2 9/32 in., 23/32 by 2¾ by 3 59/64 in., and 1 by 3½ by 6 in. Design options include various striker designs and light, medium, and heavy-duty lock designs, with 90 or 180 deg rotation. Actuator member styles include wing and hex nut types. Modified hinge constructions.

Source: Simmons Fastener Corp., Albany, N. Y.

(See Ad, Page 163)

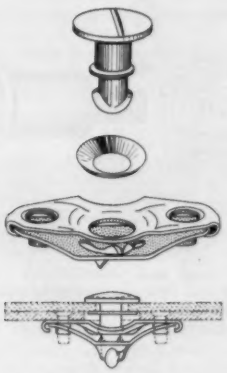
Lion Quarter Turn

Form: Three-piece, quarter-turn fastener: Stud, grommet, and preassembled receptacle. To lock or unlock, stud is rotated quarter turn. In the locked position, stud rests against positive stop.

Design Features: Positive stop prevents over torque. Spring protects against vibration. Floating action tolerates misalignments of 0.070 in. in all directions.

Material: Steel.

Sizes: Rivet spacing 1 and ¾ in. Stud diameter, 0.156, 0.195, and 0.290 in. Range of panel thickness, 0.050 to 1.009 in. Light, medium, and heavy-duty designs. Stud head styles include flush, oval, wing, ring, knurled, notched, and key. Miniature series with 0.812 by 0.375 by 0.012 envelope dimensions includes designs for material thicknesses from 0.040 to 0.159 in.



Source: Southco Div., South Chester Corp., Lester, Pa.

(See Ad, Page 165)

Milson Structural Panel Fastener

Form: Three-piece, multiple-turn fastener: Internally threaded sleeve bolt, retainer ring, and preassembled receptacle. Sleeve bolt is inserted through panel to engage threaded stud on interior of receptacle and is then rotated to lock assembly.

Design Features: Used primarily in stressed-panel assemblies. Double-lead thread in sleeve bolt provides rapid connect or disconnect. Closes gaps up to 0.125 in. with four or less turns. Tolerates misalignments up to 0.040 in. Sleeve bolt winds itself out of panel when disconnected to eliminate bind. Retaining ring holds bolt sleeve captive. Deep hex socket facilitates tool insertion and power driving. Provides prevailing torque locking action.

Materials: Alloy steel and corrosion-resistant steel.

Sizes: ¼, 5/16, and ⅜ in. shank diameters. Range of panel thickness, ⅛ to 1⅛ in. Modified designs include various receptacle types.

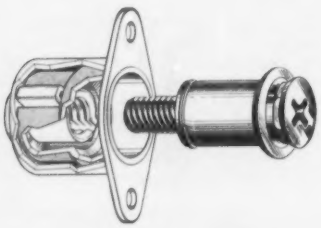
Sources: Standard Pressed Steel Co., Jenkintown, Pa. and Voi-Shan Mfg. Co., a Div. of Voi-Shan Ind. Inc., Culver City, Calif. Photo, courtesy Voi-Shan Mfg. Co.

Monadloc

Form: Two-piece, quarter-turn fastener: Receptacle and preassembled screw and bushing. Quarter turn of screw in receptacle fastens panels together. Take-up of panels is accomplished by tightening screw.

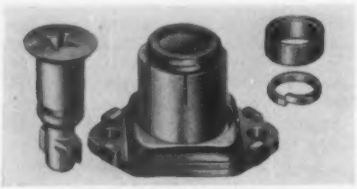
Materials: Carbon and alloy steels.

Sizes: Bushing diameter, ⅜ in. Rivet spacing ⅞ in. Range of panel thickness,



0.140 to 0.924 in. Design options include button head and countersunk bushings, Phillips and Fearson recessed-head screws.

Source: Monadnock Mills, Subsidiary of United-Carr Fastener Corp., San Leandro, Calif.



Paneloc High Performance

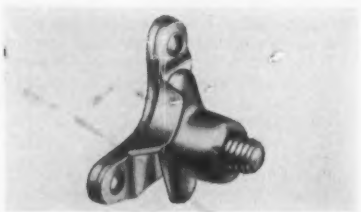
Form: Four-piece, quarter-turn fastener: Stud, retaining ring, lockwasher and receptacle. Quarter turn of stud in receptacle locks panels in place.

Design Features: High-shear strength. In unlocked position, stud is ejected by spring pressure. Receptacle is adjustable.

Materials: Steel.

Sizes: Stud diameters, ¼ and 5/16 in. Rivet spacing, ⅞ and 1 in. Range of panel thickness, 0.040 to 0.892 in. Stud head styles include flush and oval types. Rigid and floating receptacles.

Source: Scovill Mfg. Co., Waterbury, Conn.



Paneloc Rotary Latch

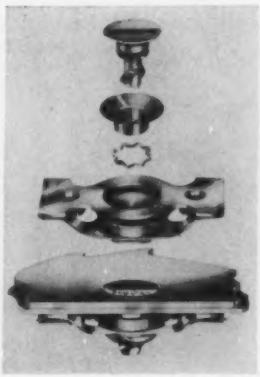
Form: Four-piece, quarter-turn latch: Latch screw, shim plate, anchor block, and nut. Shim plate and anchor block are fastened to panel. Latch screw is inserted through assembly to engage nut. Nut provides prevailing-torque locking action on screw. Quarter turn of screw locks nut lug against mating panel.

Design Features: Unit assembled on one panel. Screw design permits assembly to be tightened in place after engagement.

Materials: Steel.

Sizes: Screw diameters, No. 6-32 to 5/16-24. Screw to rivet spacing, 0.338 to 0.503 in. Stud head styles include round, flush, and wing. Nut styles include nylon-insert or all-steel self-locking types.

Source: Scovill Mfg. Co., Waterbury, Conn.



Paneloc Standard

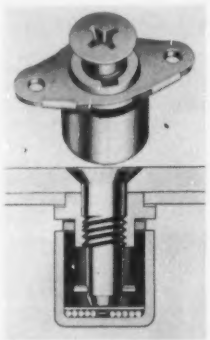
Forms: Three-piece, quarter-turn fastener: Stud, retaining ring, and receptacle. Wings, integrally forged on shank of stud, lock assembly when stud is rotated quarter turn in receptacle.

Design Features: In locked position, assembly resists vibration. No special assembly tools required. Floating receptacle accommodates misalignment.

Materials: Retaining ring is steel; receptacle assembly is aluminum and steel.

Sizes: Stud diameters, 5/16 and ⅜ in. Rivet spacing 1 and 1⅜ in. Range of panel thickness, from 0.01 in. up. Design options include light, medium, and heavy-duty types. Stud head styles include flush, oval, wing, and protruding types. Rigid and floating receptacles. Ejector springs, grommets, and shear washers.

Source: Scovill Mfg. Co., Waterbury, Conn.



Pastushin Full-Shear Stress

Form: Two-piece, quarter-turn fastener: Stud and retainer assembly. Locking pin is centered in stud shank after insertion through panel. Quarter turn of stud in retainer locks assembly.

Design Features: Positive lock. Stud is ejected when unlocked. Adaptable to various panel thickness by stud-screw adjustment. Pin retains stud in panel after unlocking.

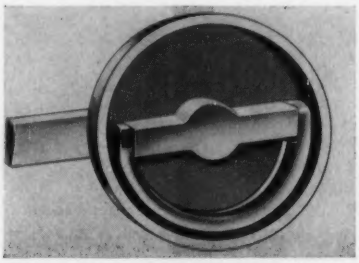
Materials: Clip and retainer, aluminum; other parts, steel.

Sizes: Stud diameter, ¼ and 5/16 in. Rivet spacing, ⅞ in.

Source: Pastushin Industries Inc., Los Angeles, Calif.

Point Catch

Form: One piece, quarter-turn latch:



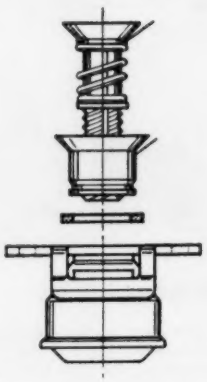
Handle and cam assembly. Latch fastens at one, two, or three points, and is controlled by one handle. Cams operate latch rods in two and three point types. Cam point engages striker in one and three point types.

Design Features: Positive closing pressure exerted by cam action. Vibration-resistant sealing action. Integral latch and handle arrangement. Latch rods provide adjustment.

Materials: Steel, aluminum, bronze, and brass depending upon manufacturer.

Sizes: Grip length, 1/16 in. and up, depending upon manufacturer. Options include various handle, cam, bolt, and mounting designs.

Source: Produced by several manufacturers. Photo, courtesy Corbin Cabinet Lock Div., American Hardware Corp., New Britain, Conn.



QAF

Form: Two-piece, partial-turn fastener: Preassembled stud and receptacle. Stud is pushed into split nut in receptacle and turned, wedging nut into tapered housing and locking assembly.

Design Features: Spring in stud assembly allows for panel separation. Resists vibration. Tensile load of 4000 lb. Stud protrudes from panel for easy detection until fastened. No special tools required.

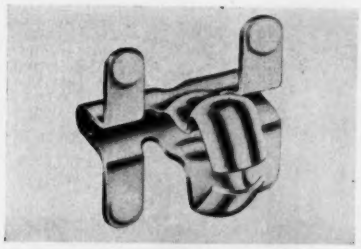
Materials: Steel.

Sizes: Rivet spacing, ⅞ in. Stud diameter, ¼ in. Grip length, 0.046 to 0.499 in. Stud head styles include flush and protruding types.

Source: Waldes Kohinoor Inc., Long Island City, N. Y.

Q-Four

Form: One-piece, quarter-turn fastener. Unit is snapped into a prepared hole in one panel, passed through elongated hole



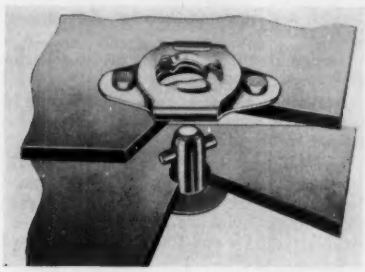
in other panel, and rotated quarter turn to lock.

Design Features: Blind application. Self-retaining.

Materials: Spring steel.

Sizes: Range of panel thickness, 0.065 to 0.225 in. Head styles include dimpled and screwdriver-slot types.

Source: Fastex, Div. of Illinois Tool Works, Des Plaines, Ill.



Q-One

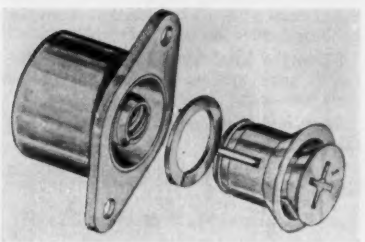
Form: Three-piece, quarter-turn fastener; Stud, cross pin, and receptacle. With the stud and pin assembled in one panel, stud is inserted in receptacle, and rotated quarter turn to lock panels together.

Design Features: Special tool necessary for pin insertion. Spring action of receptacle provides tight closure and prevents loosening under vibration.

Materials: Steel.

Sizes: Stud diameters, 0.167, 1/4, and 5/16 in. Range of panel thickness, 0.02 to 0.650 in. Stud head styles include flush, oval, and ring types. Receptacle mounting hole styles include plain, dimpled, tapped, omitted, and weld-insert types. Side-mounting bracket.

Source: Fastex, Div. of Illinois Tool Works, Des Plaines, Ill.



QR

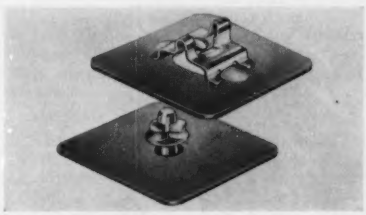
Form: Three-piece, quick-operating fastener: Screw assembly, screw retainer, and floating receptacle. Screw is inserted in receptacle and rotated to lock.

Design Features: High strength. Self-aligning. Screw is ejected when not locked. Fixed stop in receptacle holds unit within range of stud. Screw is held captive by retainer.

Materials: Screw assembly components are alloy steel; receptacle is steel.

Sizes: Screw assembly, 3/8-in. diam. Grip length, 0.150 to 1.0 in. Rivet spacing, 7/8 in. Design options include modified unit for dimpled sheet applications.

Source: Calinoy, Div. of Illinois Tool Works, Hawthorne, Calif.



Q-Two

Form: Three-piece, quarter-turn fastener: Stud, washer, and receptacle. Receptacle is snapped into prepared recesses, stud is inserted, and rotated quarter turn to lock.

Design Features: Light weight. Requires hole in one panel, and hole with two recesses in other panel. Accommodates misalignment of 1/8 in. Spring action of receptacle provides tight closure.

Materials: Receptacle and retaining washer are spring steel; stud is mild steel.

Sizes: Stud diameter, 1/4 in. Range of panel thickness, 0.030 to 0.075 in. Stud head styles include flush and wing types. Receptacle hole shapes include round, oval, and rectangular.

Source: Fastex, Div. of Illinois Tool Works, Des Plaines, Ill.

Quick-Lock

Form: Two-piece, quarter-turn fastener: Spring-loaded stud assembly and receptacle. Cam surfaces on receptacle cause stud to clamp panels as it is rotated quarter turn to positive stop.

Design Features: Initial loading is taken up by helical springs in stud assembly. Increased load is carried by stud. Stud is self-ejecting when unlocked. Screw type receptacle permits tightening of panels.

Materials: Steel.

Sizes: Stud diameter, 5/16, 3/8, and 7/16 in. Rivet spacing, 3/4, 1, and 1 1/4 in. Range of panel thickness, 0.02 to 0.259 in. Stud head styles include flush, oval, and wing types. Receptacle styles include plate and screw types.

Source: Simmons Fastener Corp., Albany, N. Y.

(See Ad, Page 163)

Rotary Synclamps

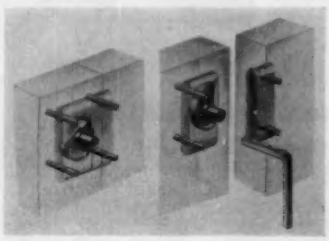
Form: Single-unit clamp assembly: Screw and a cam-like clamp with a nylon insert. The screw is turned into a tapped hole until the clamp comes into contact with the lip of the retained part. Further turning of the screw causes the clamp to bear down on the lip of the retained part, while the clamp remains stationary and the screw turns inside the nylon insert.

Design Features: Provides a panel mount for any component with a lip or rim. Once a component has been mounted, it can be disassembled by one-half turn of the screw.

Materials: 18-8 Stainless steel; insert, nylon.

Sizes: 3/8 in. diameter. Eight different clamp lengths.

Source: Timber-Top Inc., Freeport, N. Y.



Roto-Lock

Form: Two-piece, partial-turn latch: Cam unit and striker. Tapered, serrated cam in latch meshes with projections on striker when rotated partial turn.

Design Features: Load ratings to 1400-lb tension and 2000-lb shear. In case of misalignment, or if panel closure is obstructed, the latch is locked in a semiopen position. Requires Allen type wrench for operation.

Materials: Alloy steel.

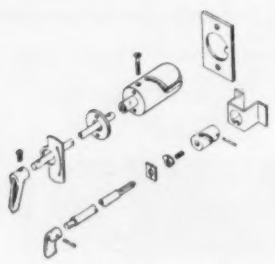
Sizes: Envelope, 3 1/32 by 3 3/8 in. Range of panel thickness, 7/16 and 5/8 in. Design options include flush and surface mounting types.

Source: Simmons Fastener Corp., Albany, N. Y.

(See Ad, Page 163)

Serve-A-Unit

Form: Five-piece, one-half turn chassis latch: Handle, washer, dowel, lock unit, and bullet-type head. Head with cam groove engages lug in the rear of chassis plate. Lug on head engages lock unit on back of rack. A dowel runs through rack and has head attached to one end, washer and handle to the other. Head engages lug as rack is pushed in, and a 180 deg



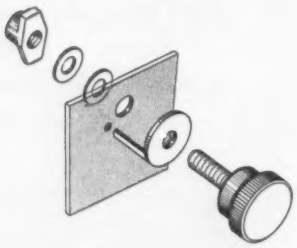
turn of handle rotates head to lock. Head is kept from turning when lug on back of head locks in lock ring.

Design Features: Cam groove provides self-alignment. Unit makes plug-in units speedily accessible. Self-ejecting when unlocked.

Materials: Steel.

Sizes: Head diameter ½ and 1 in. Various lengths. Right or left-hand operation.

Source: Alden Products Co., Brockton, Mass.



Southco Adjustable Latch

Form: Three-piece, quarter-turn latch: Stud, pawl, and pawl nut. A quarter-turn of stud rotates nut against adjoining panel and locks assembly. Additional torque tightens panels.

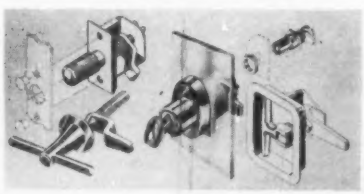
Design Features: Operates without striker plate. Adjustable grip length provided by threaded stud. Panel-thickness variations accommodated by spacer washers.

Materials: Steel.

Sizes: Stud diameter, 0.169 and 0.196 in. Max panel thickness, 1.5 in. Stud head styles include wing, round, and knurled-plastic types.

Source: Southco Div., South Chester Corp., Lester, Pa.

(See Ad, Page 165)



Southco Adjustable Pawl Latch

Form: One-piece, quarter-turn latch. Knob of preassembled unit is passed through one panel from inside. Quarter turn of handle opens or closes latch.

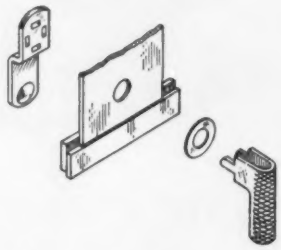
Design Features: Variations in panel thicknesses are accommodated by adjustment on the operating knob. Spring provides tight closure.

Material: Steel.

Sizes: Rivet spacing, ½, 13/16, 1¼, and 1⅞ in. Mounting hole diameter, 3/16, ⅜, ⅝, and ⅞ in. Range of panel thickness, 0 to 1⅞ in. Modified designs include recessed cup, and right and left hand types. Actuator styles include single and double knob, and slotted-flush types. Miniature series includes designs for door or frame thicknesses from 11/64 to 19/64 in.

Source: Southco Div., South Chester Corp., Lester, Pa.

(See Ad, Page 165)



Southco Door Latch

Form: Two-piece, quarter-turn latch: Pawl and actuator. Two parts are fastened together through single hole in panel. Quarter turn engages pawl.

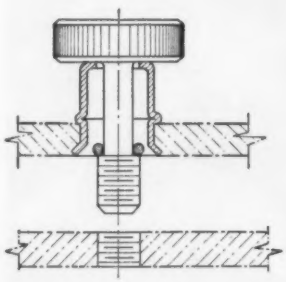
Design Features: Lightweight.

Materials: Carbon steel.

Sizes: Range of panel thickness, 0 to 11/16 in. Actuator styles include handle and screwdriver types.

Source: Southco Div., South Chester Corp., Lester, Pa.

(See Ad, Page 165)



Southco Retractable Screw

Form: Three-piece, captive stud assembly: Plastic O-ring, bushing, and threaded stud. Bushing is flanged into panel and stud inserted in over-size hole. Stud engages threaded hole in one panel and is held captive by O-ring.

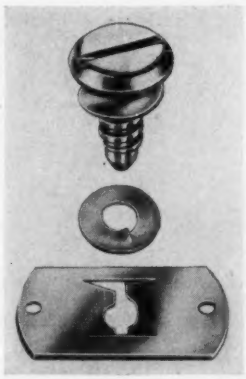
Design Features: Large hole permits stud to "float" for misalignment compensation.

Materials: Stud and bushing are brass; O-ring is plastic.

Sizes: 1/4-20, No. 12-24, No. 10-24, and No. 10-32 stud threads. Stud length, 1-3/16 in.

Source: Southco Div., South Chester Corp., Lester, Pa.

(See Ad, Page 165)



Southco Screws

Form: Three-piece, screw fastener: Screw, retaining washer, and stamped nut. Screw is inserted through panel, washer is attached, and screw is threaded into nut to lock.

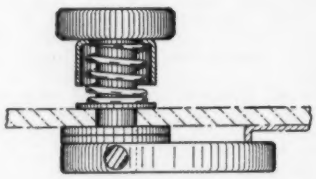
Design Features: Floating action. Washer keeps screw captive.

Materials: Screw is carbon steel; nut is carbon and corrosion-resistant steel; washers are nickel-silver.

Sizes: Screw diameter, 0.230 and 0.312 in. Screw length, 0.486 to 1.501 in. Screw head styles include knurled, wing, and slotted types. Nut styles include rivet or weld, saddle, U, and J spring-action types.

Source: Southco Div., South Chester Corp., Lester, Pa.

(See Ad, Page 165)



Southco Spring-Tension Latch

Form: Five-piece, quarter-turn, spring-loaded latch: Stud, washer, ferrule, spring, and pawl. Slight inward pressure on stud releases spring tension, and quarter turn of knob engages pawl.

Design Features: Minimum of inside operating clearance. Adjustable to various thicknesses with washer spacers. Arrow on knob indicates position of pawl.

Materials: Knob and stud are zinc; ferrule is brass; spacers are aluminum; other parts are steel.

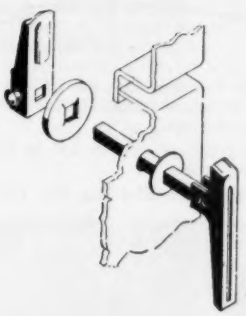
Sizes: Stud diameter, 0.257 in. Max panel thickness, 0.312 in.

Source: Southco Div., South Chester Corp., Lester, Pa.

(See Ad, Page 165)

Southco Universal Latch

Form: Four-piece, quarter-turn latch: Actuator, washer, push-on clip, and pawl. The washer is assembled on actuator stem, stem is inserted in pawl hole, push-



on clip is put on stem, and pawl is attached by set screw. Quarter turn of actuator engages pawl.

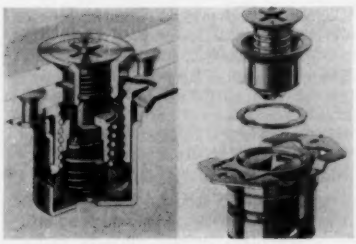
Design Features: Adjustable grip.

Materials: Steel.

Sizes: Actuator stem, 3/16-in. square. Max panel thickness, 1 3/4 in. Actuator styles include slotted-head, knob, and handle types.

Source: Southco Div., South Chester Corp., Lester, Pa.

(See Ad, Page 165)



SPF

Form: Two-piece, partial-turn fastener: Stud with pre-assembled bushing, and receptacle with threaded insert. As stud is rotated, stud lugs first engage insert and then insert moves down in receptacle, locking panels together.

Design Features: Continuous thread engagement is maintained by retained insert. Shear loads are carried by bushing. Stud too long or too short will not fasten. Vibration resistant. Floating receptacle accommodates tolerances.

Materials: Steel.

Size: Stud diameter, 3/8 in. Rivet spacing, 7/8 and 1 in. Range of panel thickness, 0.58 to 0.657 in. Head styles include flush, plus flush, and wing types.

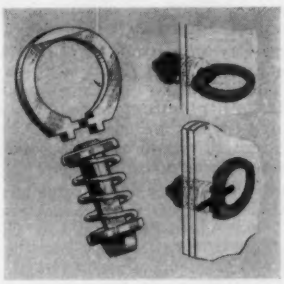
Source: Camloc Fastener Corp., Paramus, N. J.

(See Ad, Page 168)

Spring-Loaded Latch

Form: One-piece, latch assembly: Spring clip is inserted through slotted hole in the back side of the door, then D-shaped ring is slipped through end of clip to hold clip to door. Door closure is accomplished by pushing clip through slotted hole, and turning D-shaped ring a quarter turn.

Design Features: Provides low-cost fastener for cabinets and enclosures. Ring



is held firmly upright by spring tension on feet when latch is open. Spring tension eliminates noise transmission and vibration.

Material: Steel.

Sizes: Clip diam. 37/64 in. Latch mounting cutout, 3/32 by 29/64 in. Panel thicknesses up to 1/4 in.

Source: Monadnock Mills, San Leandro, Calif.

Spring-Lock

Form: Two-piece preassembled quarter-turn fastener: Rivet-like pin with locking element made of spring steel wire. Wire element is mounted to end of pin and bent back to form two flexible supports. Rotating fastener quarter turn in suitable punched panels causes the wire to flex into a spiral shape. A second quarter turn locks panels together. A third quarter turn in same direction releases assembly.

Design Features: Permanently retained. Blind application. Vibration resistant.

Materials: Locking wire is spring steel; body is steel and plastic, or plastic over metal insert.

Sizes: Stud diameter, 1/8, 5/32, 3/16, and 1/4 in. Range of panel thickness, 1/64 to 3/16 in. Head styles include oval and wing types. Clinch grommets.

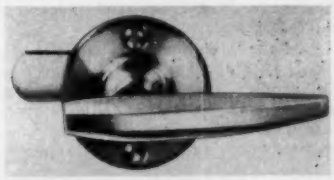
Source: Simmons Fastener Corp., Albany, N. Y.

(See Ad, Page 163)

Turn Latch

Form: One-piece, rotary latch assembly: Face plate is mounted to door or panel, rotary pawl and handle attached to rotating stem.

Design Features: Provides strong, simple, quarter-turn latch for cabinets or en-

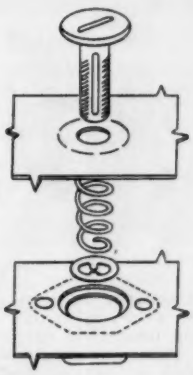


closures. Pawl is adjustable for depth of panel. Attractive appearance.

Materials: Steel.

Size: 1 7/8-in. diam. face plate. Pawl has 1 5/8 in. throw. Various panel thicknesses up to 2 in.

Source: Amerock Corp., Rockford, Ill.



Turnlock

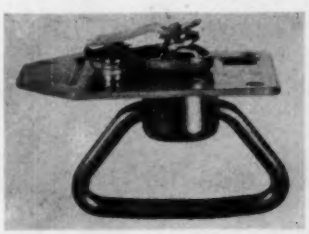
Form: Two-piece, quarter-turn fastener: Stud assembly with special interrupted thread, and receptacle. Stud is inserted through panel into receptacle. A quarter turn of stud engages threads, pulling stud into nut and locking assembly.

Design Features: Adjustable to various thicknesses. Adaptable to multiple-form strip fastening. Requires special tool.

Materials: Alloy steel.

Sizes: Stud diameter, 3/16 and 1/4 in. Stud length, 5/8, 7/8, and 1 in. Rivet spacing, 3/4 and 1 1/8 in. Head styles include flush and round types.

Source: Airtek Dynamics Inc., Compton, Calif.



Ty-loc

Form: Two-piece, partial-turn fastener: Stud and locking assembly. Stud is inserted in locking assembly, and partial turn of actuating screw locks stud in place.

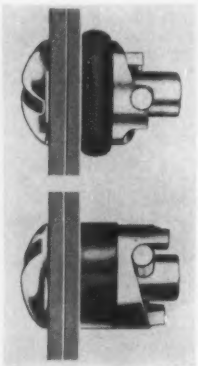
Design Features: Three-position actuating screw provides lock, open, and closed

adjustments. Plug closes stud hole when stud is removed.

Materials: Aluminum and steel.

Sizes: Stud diameter, 0.545 in. Envelope, 7/16 in. by 3-in. diameter. Stud head styles include handle and flush types. Various locking assembly shapes. Light and heavy-duty designs.

Source: Davis Aircraft Products Inc., New York, N. Y.



Vibrex

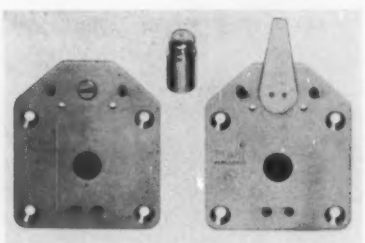
Form: One-piece, half-turn fastener: Stud, rubber sleeve, nylon cam, and pin. Assembly is inserted in prepared hole. Frictional resistance of rubber sleeve against panel and nylon cam prevents rotation of cam. A half-turn of stud causes pin to ride up cam, compressing rubber sleeve. Compressive force developed locks panels together.

Design Features: Rubber-sleeve design minimizes panel preparation. Compensates for misalignment.

Materials: Stud, cadmium or nickel-plated steel; sleeve, rubber; cam, nylon.

Sizes: 3/8 and ½ in. diameter receiving holes in base. Range of panel thickness, 1/32 to ⅜ in. Basic styles include flush, cushion, button, and shock mount types. Stud head styles include slotted, wing, ring, and special types.

Source: General Tire and Rubber Co., Industrial Products Div., Wabash, Ind.



Wedjit

Form: Two-piece, partial-turn fastener: Stud and snap release mechanism with holding device. Stud is locked in place when pushed into receptacle hole. A 40-deg turn of release mechanism unlocks stud.

Design Features: Vibration-resistant fastener. Operation unaffected by dirt or foreign matter.

Materials: Plates are aluminum; jaws, mechanism, and studs are steel.

Sizes: Clearance required for operating mechanism, 13/32 by 1 5/8 by 3 1/8 in. Stud diameter, 0.545 in. Design options include flush or surface mounting styles. Actuating types include screw head, thumb-turn, or kick-turn. Various mounting plate shapes and stud types.

Source: Monadnock Mills, subsidiary of United-Carr Fastener Corp., San Leandro, Calif., and Adams-Rite Mfg. Co., Glendale, Calif. Photo, courtesy Monadnock Mills.

Zip-Loc

Form: Three-piece, partial turn fastener: Stud nut with hex socket, receptacle, and retaining ring. Stud nut, which has quadruple-lead internal threads, is pushed on mating stud in receptacle and turned to draw parts up tight. Mating serrated surfaces on nut face and spring-loaded washer in receptacle assembly lock nut to stud in any engaged position.

Design Features: Floating-stud design assures positive alignment with nut. Can accommodate misalignments up to 0.020 in. in nut-carrying panel. Provides double shear strength of 15,000 lb and can withstand tension loads up to 3,800 lb. Gives full takeup in maximum of 1 1/3 turns. Maximum operating temperature is 550 or 700 F, depending on part materials.

Materials: Stud nut is 8740 steel or Type 431 stainless steel; receptacle is 8740 (stud) and 1010 (components) steel or all Type 431 stainless steel; retaining ring is Elgiloy.

Size: Nominal diameter of stud-nut is ⅜ in. Envelope approximately 1¼ by ⅝ in. with ⅝ in. back clearance. Grip lengths 1/16 to 1 in.

Source: Deutsch Fastener Corp., Los Angeles, Calif.

Lever-Actuated Types

Adams-Rite Over-Center Latch

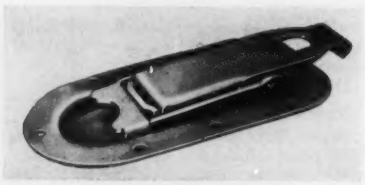
Form: One-piece, tension-latch assembly used with strike or lip on panel. The strap is engaged in lip or striker and lever is depressed, pulling units together. Strap tension holds latch closed.

Design Features: Requires 10-lb latching force. Withstands load of 250 lb.

Materials: Steel.

Sizes: Envelope, 0.56 by 0.91 by 3.58 in., excluding strike.

Source: Adams-Rite Mfg. Co., Glendale, Calif.



Bassick Spring-Loaded Clamp

Form: One-piece, recessed, tension-latch assembly used with or without a strike: Recessed base plate, actuating lever, engagement strap, and two coil springs. Free end of the strap is hooked over lip or strike, lever is depressed, and cam action pulls components together. Tensile pull is exerted on engaging strap by coil springs.

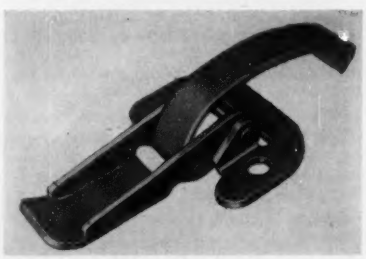
Design Features: Recessed base provides flush mounting. Multiple 70-lb springs cushion operation of unit and provide constant tension. Linkage mechanism adjusts for mounting discrepancies.

Materials: Steel alloy.

Sizes: Envelope, 0.66 by 2.22 by 4.39 in. to 0.55 by 2.38 by 5.66 in., excluding strike. Modified designs include various base and strap configurations.

Source: Bassick Co., Div. of Stewart-Warner, Bridgeport, Conn.

(See Ad, Page 166)



Bassick Strap Spring Clamps

Form: Two-piece, tension-latch assembly: Strike and base unit. To operate latch, actuating lever is placed in up position, free end of strap spring is engaged in strike, and lever is depressed. Pressure applied to strap pulls mating parts together, and spring force in strap holds latch closed.

Design Features: 50 to 75-lb closing pressure.

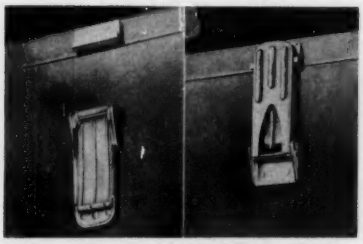
Materials: Steel alloy.

Sizes: Surface demensions, 1 7/8 by

2 29/32 in. to 1 7/8 by 3 5/8 in. excluding strike. Modified designs include various strike and base configurations. Strap designs include hook, loop, or hinge types.

Source: Bassick Co., Div. of Stewart-Warner Corp., Bridgeport, Conn.

(See Ad, Page 166)



Camloc Container Latch

Form: Two-piece toggle latch assembly: Drawhook is placed in strike which is attached to cover and lever is depressed, pulling cover to closed and locked position. Raising lever releases drawhook from strike.

Design Features: Ultimate strength is 1000 lbs. Over-center toggle provides increased mechanical advantage. Drawhook stows flat within handle when latch is fully open.

Material: Drawhook and handle are steel. Base and hook are steel or aluminum.

Size: Envelope: Maximum dimensions of 2⅝ in. wide, 5½ in. long, ¾ in. deep.

Source: Camloc Fastener Corp., Paramus, N. J.

(See Ad, Page 168)

Camloc Electronic Chassis Latch

Form: Two-piece latch assembly: Fork attached to rack, and handle unit attached to chassis by handle plate. Removal of the unit is accomplished by depressing button on top of handle to release lock, pulling handle down to disengage chassis from rack, pulling chassis out, and returning handles to locked position. Installation is accomplished by opening handle, pushing chassis in until handles engage fork, and raising handles into locked position.

Design Features: Combines latch and handle in one assembly. Provides quick release and lock operation. Max horizontal load per latch is 600 lb ultimate.

Materials: Aluminum alloy or zinc alloy.

Sizes: Minimum required panel height, 5¾ in.

Source: Camloc Fastener Corp., Paramus, N. J.

(See Ad, Page 168)

Camloc Heavy Duty Latch

Form: Two-piece tension latch: Handle and shear-pin units. Closure is accomplished by engaging drawloop in shear-pin seat, pulling latch handle back, engaging shear-pin in handle unit, returning cover handle to closed position by releasing trigger, and locking assembly with quarter-turn fastener.

Design Features: Shear pin corrects for angular approach of mating members. Overloading of panel automatically retracts shear pin. Pin and bushings withstand up to 10,300-lb tension and 8000-lb shear, Shear pin can be adjusted to compensate for wear.

Materials: Steel.

Sizes: Surface dimensions, 1⅛ by 4 9/16 in. to 2⅛ by 8 3/16 in. Max panel separation, ⅝ in. Modified designs for various load and environmental conditions.

Source: Camloc Fastener Corp., Paramus, N. J.

(See Ad, Page 168)

Camloc Push Button Latch

Form: One-piece, tension latch used against panel stop or strike. Operation of button pivots lever and rotates bolt head into cage to open. Bolt head is returned to strike by spring-action when button is released.

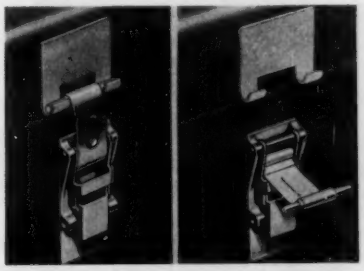
Design Features: Raised center of push-button permits flush mounting.

Materials: Carbon or stainless steels.

Sizes: Envelope, 11/16 by 1⅜ by 2 in. and 11/16 by 1 5/16 by 2 1/16 in. Modified designs include various cage and lever configurations.

Source: Camloc Fastener Corp., Paramus, N. J.

(See Ad, Page 168)



Camloc Toggle-Tension Latch

Form: One-piece, cam-action, spring latch assembly used with strike or lip. Drawhook is placed in strike, and lever unit is depressed to close and lock assembly. To open, release lever is raised, lifting primary lever by cam action. Entire lever unit is then raised to disengage drawhook.

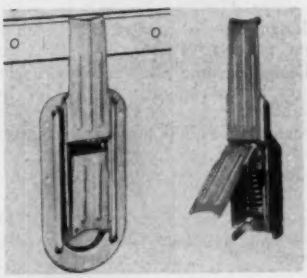
Design Features: Ultimate strength of 150 lb. Shallow envelope permits face-to-face storage of equipment. Latch may be lockwired in closed position.

Materials: Base, aluminum; other parts, steel.

Sizes: Envelope, 3/16 by 21/32 by 1⅞ in., and 3/16 by 21/32 by 1 9/16 in. Drawhook styles include hook and pin types. Modified designs include various base and drawhook configurations.

Source: Camloc Fastener Corp., Paramus, N. J.

(See Ad, Page 168)



Clench Catch

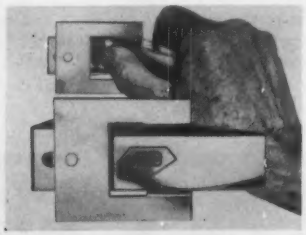
Form: One-piece latch assembly. Hooked tongue on catch fits over lip or flange on lid of case or enclosure. To open, flat handle underneath tongue is raised, releasing the spring pressure on the tongue and allowing it to move up, then pivot outward to release lip.

Design Features: Reinforcing ribs embossed in tongue and handle allow catch to withstand forces from any angle. Designed for one-handed operation, with or without gloves.

Material: Steel.

Size: Closing distance approximately ⅜ in. Envelope approximately 6¼ by 2 by 9/16 in.

Source: J. H. Sessions & Son, Bristol, Conn.



Combination Catch and Pull

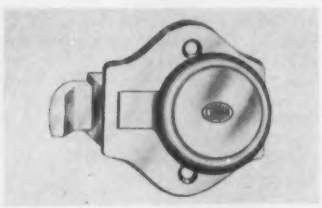
Form: One-piece latch assembly: Finger operated sliding bolt uses lip of cabinet as strike. Bolt and operating lever are attached to mounting plate which sets flush in cabinet. Operating lever is pushed in, then pulled to open.

Design Features: Provides easily operated, flush-mounted, positive-locking latch for cabinets and sheet-metal enclosures. Does not require mounting of separate strike.

Materials: Steel.

Size: Envelope approximately ¾ by 4½ by 2¼ in., back clearance included.

Source: Amerock Corp., Rockford, Ill.



Corbin Panel Board Catch

Form: One-piece pull latch used with or without strike. Latch is opened by pulling ring which disengages latch bolt from panel or strike.

Design Features: Reversible. Panel requires special hole to provide for flush mounting.

Materials: Pull is brass; other parts are steel.

Sizes: Envelope, 7/8 by 1 11/16 by 2 5/32 in.

Source: Corbin Cabinet Lock Div., American Hardware Corp., New Britain, Conn.

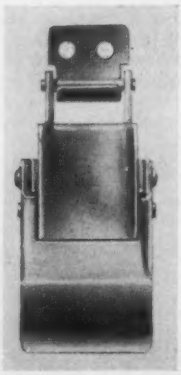
Draw Bolt

Form: One-piece, spring-latch assembly used with strike. Free end of bolt loop is hooked over strike. Lever is depressed and bolt loop pulls sightly out of housing, compressing springs, to lock.

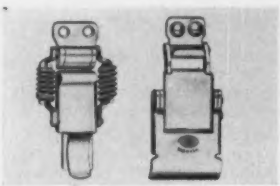
Design Features: Provides locking force from 42 to 100 lb. Accidental release is prevented by spring action and housing design.

Materials: Steel and stainless steel.

Sizes: Typical surface dimensions, 3/8 by 1 1/4 in. to 1 1/8 by 3 in., depending upon manufacturer. Modified designs include various strike and base configurations.



Source: Produced by several manufacturers. Illustration courtesy of Excelsior Co., Stamford, Conn.



Draw-Pull Catches

Form: One-piece, tension latch used with strikes. Free end of loop is hooked over strike, and parts are pulled together when the lever is depressed. Unit is locked under tensile force of wire or by springs.

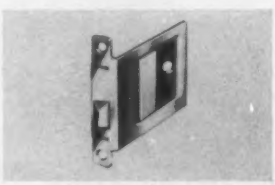
Design Features: Develops spring tension from 20 to 100 lb. Assembly adjusts to proper holding position.

Materials: Steel and brass.

Sizes: Typical envelope, 5/8 by 7/8 by 1 5/16 in. to 1 by 1 3/4 by 3 3/4 in., depending upon manufacturer. Modified designs include concealed-spring type, and various strike and base configurations.

Source: Produced by several manufacturers. Photos, courtesy of Corbin Cabinet Lock Div., American Hardware Corp., New Britain, Conn.

(See Ad, Page 167)



Flush Latch

Form: Single-unit latch assembly: Spring loaded bolt uses lip of cabinet or panel as strike. Bolt is retracted by pulling flap handle outward. Flap handle also used as pull for drawer or door.

Design Features: Requires no strike plate when used with sheet metal enclosures. Lock cylinder can be added. Can be used horizontal or vertical.

Materials: Chrome plated brass or stainless steel.

Size: Approximately ¾ in. back clearance required. Envelope, 1⅜ or 2 by 1¾ or 3 in. ¼ to 5/16 in. bolt travel.

Source: Adams-Rite Mfg. Co. Inc., Glendale, Calif.

(See Ad, Page 166)

Gear-Lock

Form: One-piece, worm-gear clamp used with or without strike. Rotation of the locking nut turns worm gear and drops engaging link into strike or panel. Further rotation clamps link in place.

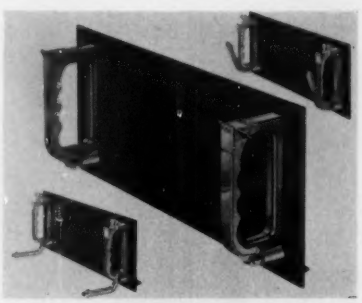
Design Features: Withstands heavy shock, vibration, and loads. Closing pull of 2000 lb. Locking nut requires standard wrench for tightening.

Materials: Steel alloy.

Sizes: Length, 3 7/8 to 8 3/8 in. Modified designs include external, external recessed, and internal types.

Source: Bassick Co., Div. of Stewart-Warner Corp., Bridgeport, Conn.

(See Ad, Page 166)



Gripwell Latch

Form: Two-piece latch assembly: Keeper attached to rack or structure, and handle unit attached to chassis. Opening of the unit is accomplished by moving unlock indicator up, then depressing trigger, allowing the locking bar to move out and unlock the keeper. To close, locking bar is pushed in and unlock indicator is placed over trigger.

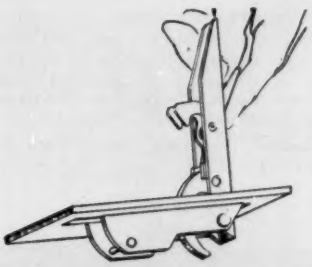
Design Features: Provides a handle and latch for modular electronic chassis. Handle is available for carrying in either latched or unlatched position. Will tolerate misalignment, and is adaptable to O-ring sealing.

Materials: Springs and keeper are steel; housing aluminum.

Size: Envelope approximately 3 by 6 by ⅝ in.

Source: Hartwell Corp., Los Angeles, Calif.

(See Ad, Page 164)



Hartwell Hook Latch

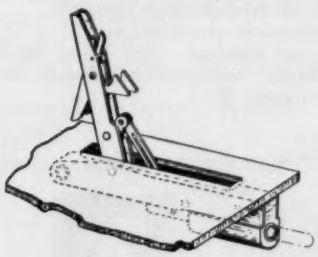
Form: One-piece, toggle-action, hook latch. Opening of release trigger permits body of latch to rotate about pivot pin, which permits hook to swing clear of engaging pin.

Design Features: Two-pin action insures against accidental opening. Cam provides force for closing.

Materials: Steel and aluminum alloy.

Sizes: Cutout dimensions, 1 by 4 5/32 in. and 1¼ by 6 9/16 in. Modified designs include single, double, adjustable, and cowl-hook types.

Source: The Hartwell Corp., Los Angeles, Calif.



Hartwell Pin Latch

Form: One-piece, sliding-bolt latch. Latch is opened when release panel is depressed to disengage hook. Operating lever is then lifted, retracting pin type bolt. Closure is accomplished by depressing lever back to flush position, reengaging bolt and release-panel hook.

Design Features: Double-locking action prevents accidental opening. Pin engagement permits latch to be used as pivot. Bolt stop limits bolt retraction. Tapered pin assures complete closing.

Materials: Steel and aluminum.

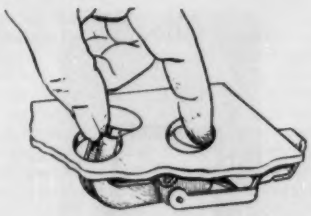
Sizes: Cutout dimensions, 9/16 by 4½ in. to 1 5/32 by 5 9/16 in. Modified designs include various mounting, handle, and pin configurations.

Source: The Hartwell Corp., Los Angeles, Calif.

Hartwell Self-Closing Latch

Form: One-piece, bolt latch. Release panel retracts bolt through mechanical linkage when depressed. Bolt is returned through spring action.

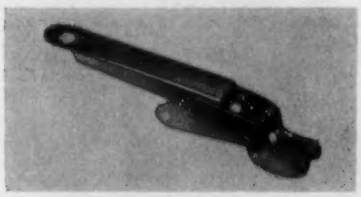
Design Features: Bolt is automatically reset when door or panel is closed. Positive closure when door is slammed.



Materials: Steel and aluminum.

Sizes: Envelope, 0.52 by 1½ by 2 13/32 in. and 0.59 by 1½ by 3 11/32 in. Modified designs include various base-unit and handle configurations.

Source: The Hartwell Corp., Los Angeles, Calif.



Hartwell Toggle Bolt Latch

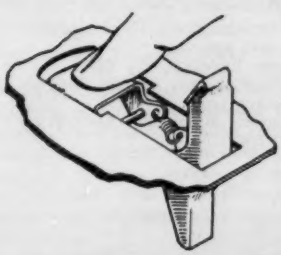
Form: One-piece, toggle latch. Lever handle is depressed and catch unit swings up to engage hook or flat bearing surface. Lever handle is lifted to disengage hook. Latch is secured in closed position by flush stud fastener through lever handle.

Design Features: Swing-up action provides vertical force to compress panel in place.

Materials: Steel and stainless steel.

Sizes: Cutout dimensions, 15/16 by 5 3/16 in. Modified designs include various body, handle, link, and hook styles.

Source: The Hartwell Corp., Los Angeles, Calif.



Hartwell Trigger-Action Latch

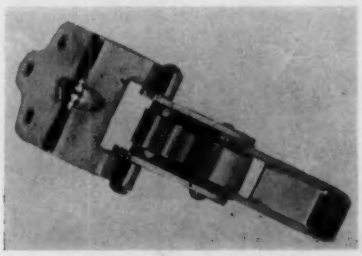
Form: One-piece, bolt latch. Latch is opened by depressing a trigger to release bolt which swings 90 deg under spring action. Closure is accomplished by moving the bolt back into position.

Design Features: For use in thin and medium-thickness panels.

Materials: Steel, aluminum, and stainless steel.

Sizes: Cutout, 1 1/16 by 1 9/32 in. to 2¾ by 3 19/32 in. Modified designs include various mounting, body, bolt, and release configurations.

Source: The Hartwell Corp., Los Angeles, Calif.



Hinge Clamp

Form: Two-piece, tension latch: Strike and base unit. Strike bar is inserted in pronged end of base unit and strap hook is placed over strike bar. When lever is depressed, components are pulled together and locked under tension of spring strap.

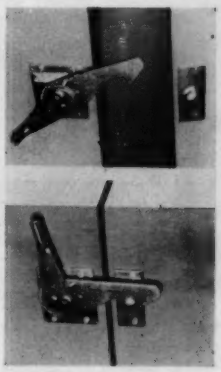
Design Features: Pronged base and hook on strap permit the fastener to be used as hinge when in closed position. Spring strap is protected against accidental tripping by high base sides.

Material: Steel alloy.

Sizes: Surface dimensions, 15/16 by 3 9/32 in. Modified designs include various strike and base configurations.

Source: J. H. Sessions and Son, Bristol, Conn., and Bassick Co., Div. of Stewart-Warner Corp., Bridgeport, Conn. Photo, courtesy of J. H. Sessions and Son.

(See Ad, Page 166)



Hook-Lock

Form: Two piece latch assembly: Strike-pin assembly screwed to cover, latch-hook assembly screwed to base. To close cover, operating lever is moved through an angle of about 100 deg. causing a pin on the operating lever to move in a slot in the hook plate. At first the pin cams the hook plate down, then an over-center motion completes the closure.

Design Features: Positive locking without springs. Provides a closing pressure of 200 lb. Load carrying capacity is 750 lb. Lies flat against the case whether open or closed.

Material: Steel.

Size: Envelope 7/16 by 4 1/16 by 6 5/16 in. Closing distance, ¼ in.

Source: Simmons Fastener Corp., Albany, N. Y.

(See Ad, Page 163)

Missile-Air Latch

Form: One-piece latch assembly. Finger-operated, flush mounted. Latch is opened by pushing in on larger of two finger plates, closed by pushing on the smaller.

Design Features: Over-center action prevents accidental opening. Only finger-tip pressure is required to open latch. Accommodates misaligned mounting or panels. No special cutouts required in panel.

Materials: Stainless-steel frame and aluminum push-buttons.

Sizes: Panels or doors, 0.040 to 0.313 in. thick. Envelopes, 0.93 by 3⅛ by 9/16 in. and 1.35 by 3 13/16 by 1 9/16 in. Body styles include models with large and small finger plates.

Source: United States Chemical Milling Corp., Manhattan Beach, Calif.

Nielsen Catch

Form: One-piece, loop latch used with striker. Depression of release plate permits latch to open. Loop is then withdrawn from striker.

Design Features: Protected against accidental release. Withstands loads to 3000 lb. Resists accidental release due to shock or vibration. Latch grip length is adjustable to facilitate assembly.

Materials: Aluminum and steel.

Sizes: Envelope, ¾ by 2¼ by 4 27/64 in., excluding striker. Design options include recessed and nonrecessed plate designs, various latch and base configurations.

Source: Nielsen Hardware Corp., Hartford, Conn.

(See Ad, Page 167)

Sessions Spring Catch

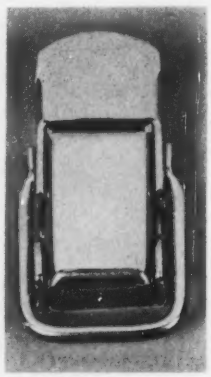
Form: Two-piece, spring latch: Base unit and striker. Engagement loop is hooked over striker and lever is depressed, closing unit against force of springs. To open, the finger tab is lifted, moving main housing away from base. Lever unit is raised to unhook loop.

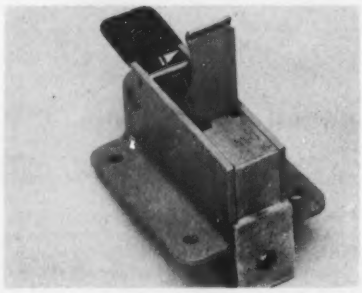
Design Features: Accidental release prevented by spring action. Engagement loop has 70-lb preload which increases to 100 lb when loop is deflected.

Materials: Steel.

Size: Envelope, 3/4 by 1-3/4 by 4 in.

Source: J. H. Sessions and Son, Bristol, Conn.





Simmonds Bolt Latch

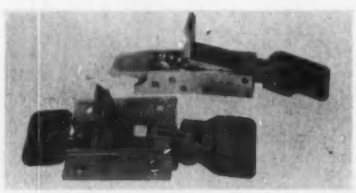
Form: One-piece, bolt latch. Depression of spring-loaded actuating tab releases bolt lever, retracting bolt. Closure is accomplished by depressing bolt lever, which locks under release tab.

Design Features: Develops shear strength of 4500 lb. Large bolt travel for small lever movement.

Materials: Body is aluminum; pinion and bolt are steel.

Sizes: Envelope, 1⅞ by 2 1/16 by 4⅛. Modified designs include flush or flange mounting types.

Source: Simmonds Aerocessories Inc., Tarrytown, N. Y.



Simmonds Cam Lever Latch

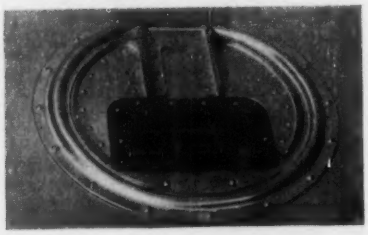
Form: Two-piece, toggle latch: Toggle member and receptacle. Latch is opened by pressing spring-loaded release lever on receptacle to unlock toggle member. A spring kicks hinged toggle up to provide a lever for raising toggle unit.

Design Features: Toggle working length is adjustable. Self-closing.

Materials: Aluminum and steel alloys.

Sizes: Envelope, 1 by 1⅛ by 4⅞ in. to 1¾ by 2 by 7½ in. Modified designs include flush types for general-purpose and high-strength applications.

Source: Simmonds Aerocessories Inc., Tarrytown, N. Y.



Simmonds Panel Latch

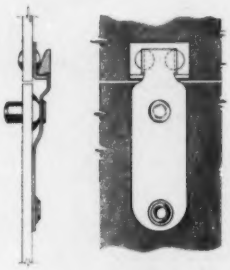
Form: One-piece, latch assembly. Depression of treadle releases latching mechanism. Panel is then removed as hand is withdrawn.

Design Features: Serves as a handle as well as a latch. Large push area facilitates opening. Catch area is balanced against air pressure. Latch remains captive in panel which is removed.

Materials: Aluminum.

Sizes: Envelope, ¾ by 3⅛ by 4⅞ in.

Source: Simmonds Aerocessories Inc., Tarrytown, N. Y.



Southco Pushbutton Release Catch

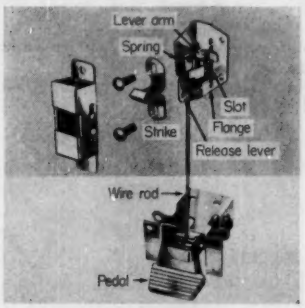
Form: Three-piece latch assembly: Keeper, release button, and spring latch. Hook on end of latch engages keeper in locked position. To unlock, release button, which projects from face of panel, is depressed to disengage latch hook.

Design Features: Latch assembly is hidden behind face of panel or cover; only the release button is visible. Provides a simple, quick-release holddown fastener for lift-off covers and similar parts. Latching action is automatic when door or cover is slammed shut.

Materials: Keeper and release button are steel; latch is spring steel.

Sizes: Envelope, 11/16 by 2¼ by 7/32 in. and ⅞ by 2½ by 7/32 in. Design options include riveted and welded types, 90 and 180 deg keeper mountings.

Source: Southco Div. of South Chester Corp., Lester, Pa.



Toe-Touch Latch

Form: Four-piece, foot-operated latch assembly: Treadle mechanism mounts to bottom of unit, release mechanism is connected by wire rod and mounts behind lip of cabinet opening, strike mounts on front of lip, and double nylon-roller catch assembly mounts on the back side of the door. Actuation of foot treadle causes the release mechanism to nudge the double nylon-roller catch free of the strike, and the door swings open. Spring-loaded release lever returns to neutral position when treadle is released.

Design Features: Provides an easily-opened door latch with a firm locking action. Strike and release mechanism are held to cabinet lip with the same pair of screws. Mechanism will release or engage under 10 lb pressure applied to the back side of door.

Materials: Steel mechanism, nylon rollers.

Source: Amerock Corp., Rockford, Ill.

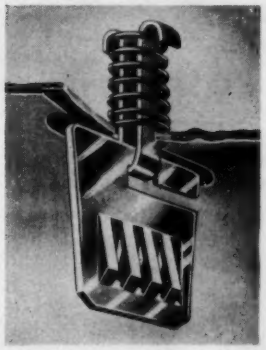
allowing stud to be spring ejected.

Design Features: Visual inspection reveals a safe lock since fastener is automatically spring ejected if not fully seated. Panels remove by spring ejection, without prying, when release button is depressed. Stud mounts completely flush with panel surface. No special tools required; any small pointed object such as nail or ballpoint pen can be used to release fastener. Stud snaps in place for insertion; no threading or turning is required.

Materials: Alloy steel or corrosion-resistant steel.

Size: 1/4 to 3/8 in. Stud styles include normal and heavy duty.

Source: Avdel, Inc., Burbank, Calif.



Lite-Lok

Form: Three-piece, sheet-metal slide fastener: Tab, yoke, and spring. Unit is installed by slipping the spring over yoke, inserting yoke through hole in frame, and sliding tab into yoke where it is retained by a notched seat. Tab is passed through slot in panel, turned 90 deg, and flipped flat against the sheet.

Design Features: Eliminates thumbscrews. Requires no special assembly tools.

Materials: Spring steel.

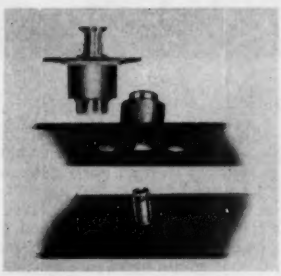
Sizes: Range of panel thickness, up to 5/32 in.

Source: Southco, Div. of South Chester Corp., Lester, Pa.

Nylatch Fastener

Form: Two-piece slide fastener: Plastic grommet and metal pin. Plastic grommet is pressed into prepared hole in sheet, then pin is pressed into the grommet, forming a bulbous head on the back side

Slide-Action Types



Avdel Flush-Mounting Fastener

Form: Two-piece snap fastener: Stud and receptacle. Stud is permanently attached to panel. Receptacle is anchored to chassis or frame of assembly. Four locking balls in stud expand beyond diameter of stud when inserted, locking against a shoulder in receptacle. To release, recessed center of stud head is pressed with pointed object, causing balls to retract and

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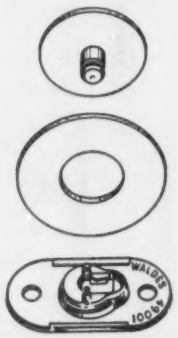
of the sheet. When pin is pulled out of grommet it returns to original shape.

Design Features: Used for all purpose fastening of sheet materials. Requires no tools to assemble or disassemble. Can tolerate total misalignment of 0.040 in. Rated at 60 lb tension load. Head styles include "Easy-grip," "Momo-grip," and "Tamper-proof".

Materials: Grommet, nylon; pin, aluminum.

Size: For combined sheet thicknesses 0.087 to 0.200 in. Requires about 11/16 in. back clearance.

Source: Hartwell Corp., Los Angeles, Calif.



PLF

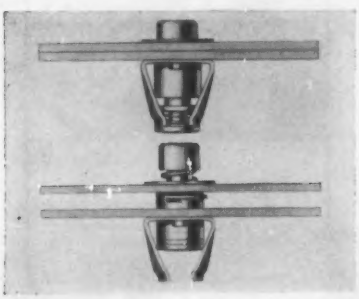
Form: Three-piece, snap fastener: Stud subassembly, washer and receptacle. When stud and housing subassemblies are engaged, a retaining ring locks stud to housing. Stud is released by pushing it down into receptacle and then toward open end. When stud is pressed deeper into receptacle, locking spring is compressed and stud is shifted out of retaining ring.

Design Features: Locks against any combination of forces. Stud subassembly floats ¼ in. in any direction.

Materials: Stud is stainless steel; washer is aluminum; receptacle is steel.

Sizes: Envelope, 0.370 by 1 by 1⅞ in. Washer diameter, 1¾ in. Stud diameter, 1-3/16 in. Modified designs include horizontal and vertical types.

Source: Waldes Kohinoor Inc., Long Island City, N. Y.



Pres-Loc

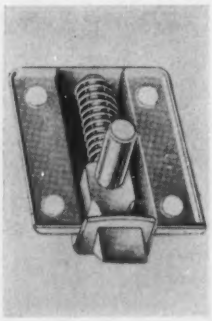
Form: Three-piece, slide fastener: Receptacle, retaining ring, and preassembled stud unit. Stud is inserted through panel to engage receptacle and stud button is then pressed to lock assembly. To unlock, button is pressed to force spreader between receptacle leaf springs, permitting unit removal.

Design Features: Requires no special tools for installation. Retaining ring holds stud assembly captive.

Materials: Steel.

Sizes: Stud diameter, 0.386, 0.453, and 0.515 in. Range of panel thickness, 0.62 to 1.87 in. Stud styles include protruding, flush, and flange button types.

Source: Deutsch Fastener Corp., Los Angeles, Calif.



Slidebolt

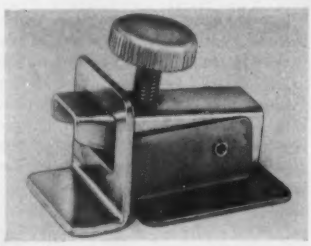
Form: One-piece, bolt latch used with striker plate. Sliding knob actuates bolt against spring-loaded arm which keeps bolt extended when knob is released.

Design Features: Automatic return of bolt permits panel to be securely closed when slammed.

Materials: Steel, brass, and aluminum.

Sizes: Typical envelope, up to 1 by 2½ by 3 in., depending upon manufacturer. Modified designs include various housing, bolt, and actuating knobs.

Source: Produced by several manufacturers. Illustration, courtesy of Corbin Cabinet Lock Div., American Hardware Corp., New Britain, Conn.



Slide Latch

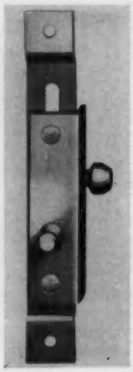
Form: Two-piece, slide latch: Pawl unit and striker. Pawl slides into striker and is tightened against striker surface by turning screw knob.

Design Features: Seals door and frame, or panel, units under pressure. Latch does not require precision alignment and tolerates variations in elements.

Materials: Steel.

Sizes: Envelope, 1 by ⅜ by 2 3/32 in., and 1½ by 1½ by 2 3/16 in. Modified designs include various housing, and mounting configurations.

Source: Southco, Div. of South Chester Corp., Lester, Pa. and Torit Mfg. Co., St. Paul, Minn. Illustration, courtesy of Torit Mfg. Co.



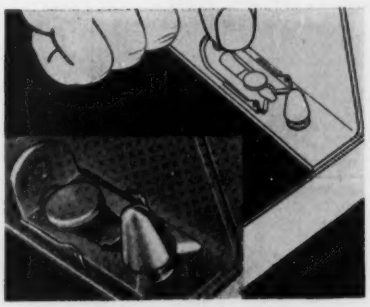
Sliding Latch

Form: One-piece, sliding-latch assembly: Slide is mounted in slotted bracket. Necked-down locking stud is attached to slide. By moving slide up, the locking stud engages a hole in the frame.

Design Features: Provides low-cost, reliable latch for cabinets and enclosures. Spring behind the locking stud will not allow the slide to move of its own weight.

Materials: Steel.

Source: Amerock Corp., Rockford, Ill.



Snapslide

Form: Five-piece slide fastener: Stud, guide, slide, spring washer, and button. Stud is fastened to fixed portion of panel, and guide, slide, and washer are fastened to removable panel by button rivet. To lock assembly, removable panel and guide are assembled on stud, and slide is moved forward so that pronged end of slide engages narrow section of stud.

Design Features: Requires no tools for operation. Requires no adjustment. Shockproof and vibration resistant.

Materials: Brass and steel.

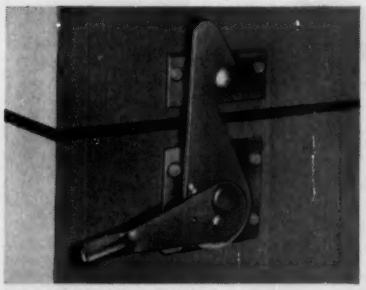
Sizes: Surface dimensions, 7/32 by 19/32 in. to 9/16 by 1 15/32 in.

Source: Produced by several manufacturers. Illustrations courtesy of Dimco-Gray Co., Dayton, Ohio.

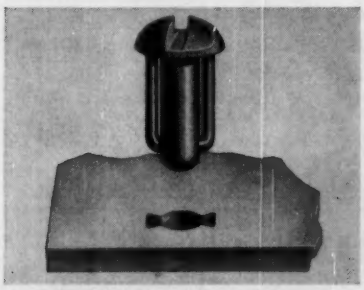
(See Ad, Page 161)

ANSWERS to specific fastening problems ...by SIMMONS

Economy, design flexibility, quick and easy installation, strength, and smooth, dependable action are advantages of these Simmons Fasteners, made for a variety of special applications. Whatever your fastening problem, engineering aid is available from Simmons.

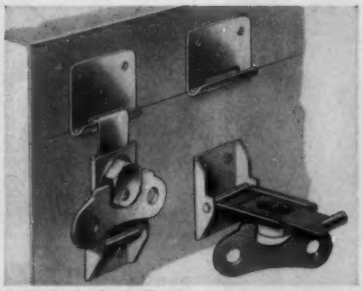


HOOK-LOCK–Springless, positive-locking latch which lies flat against mounting surface, open or closed. Provides high closing pressure and load-carrying capacity. For military as well as commercial container applications.

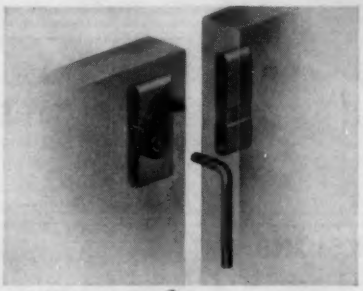


SPRING-LOCK–Perfect, proved blind rivet for removable covers and panels on electric and electronic equipment, sheet-metal automobile parts, appliances.

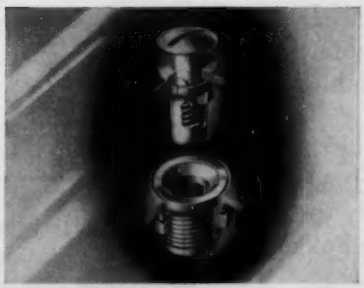
Plastic Spring-Lock Shelf Supports with "heart of steel" help refrigerator makers cut costs, speed production, simplify servicing.



LINK-LOCK–Ideal latching device where heavy locking pressure is necessary. Available in heavy, medium, light duty, for use in military and commercial containers and demountable construction.

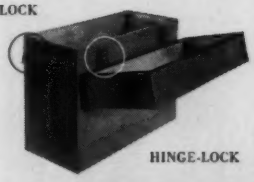


DUAL-LOCK–Impact and vibration-proof high-load butt-joint fastener that will not accidentally unlock or loosen. Recess in panels or surface mount. Withstands 7000-lb. tension.

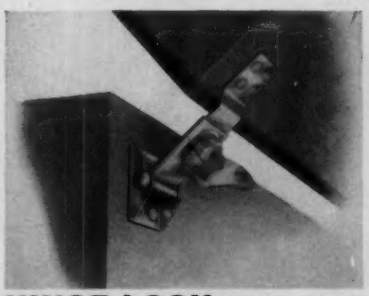


QUICK-LOCK–For assembling removable panels and access doors. Locked by a 90° turn. Various sizes and types, for weather-tight electrical units, cowlings, access panels.

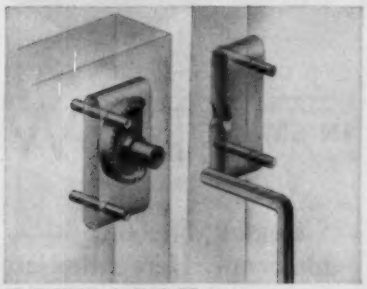
LINK-LOCK



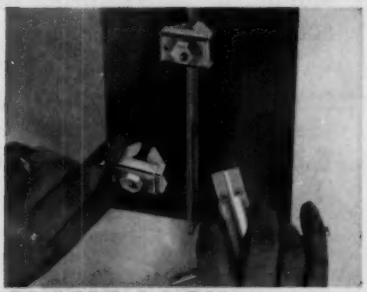
HINGE-LOCK



HINGE-LOCK–A rugged pressure hinge which provides a strong seal along the hinge line of gasketed equipment containers and transit cases. Matched hardware with LINK-LOCK.



ROTO-LOCK–Versatile fastener for butt or right-angle joints in portable shelters, partitions, knock-down shipping boxes, etc. Solidly built, springless.



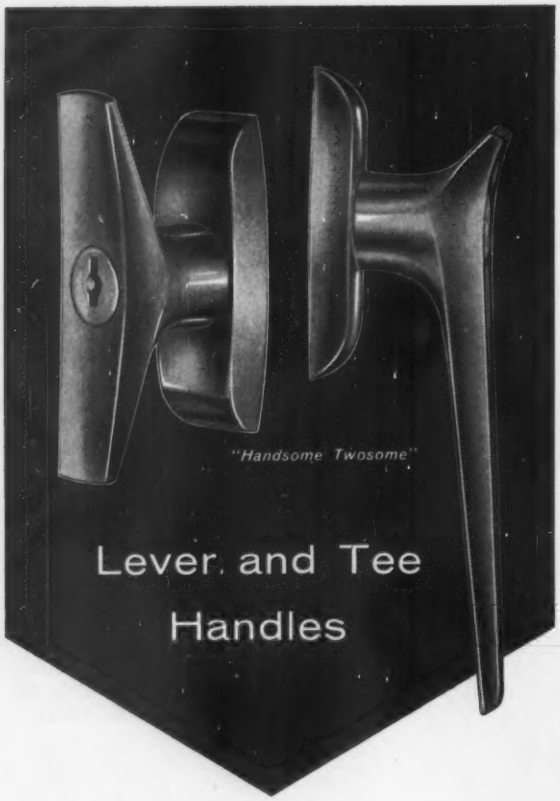
CLAMP-LOCK–A simple and strong, positive-locking clamp for fast assembly (and disassembly) of permanent or temporary rooms and buildings of flanged-panel construction.

SEND TODAY for your copy of the Simmons catalog, with specifications, applications, installation instructions for all Simmons Fasteners. Samples are available. For special assistance, describe your requirements.

SIMMONS FASTENER CORPORATION

1756 North Broadway, Albany 1, New York

See our condensed catalog in Sweet's Product Design File



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CORBIN, of course —— modern as tomorrow. Here's the latest word in Lever and Tee Handle design.

All Handles are pressure-cast. Lustrous satin-chrome finish sets the standard. Other finishes available on special order.

For a complete description of these new designs in Lever and Tee Handles, just send for CORBIN'S newly published Lever and Tee Handle Folder.

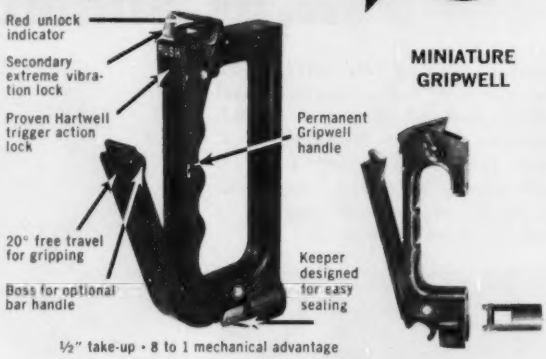
CORBIN

CORBIN CABINET LOCK DIVISION

THE AMERICAN HARDWARE CORPORATION
NEW BRITAIN, CONNECTICUT

Circle F-39 on Page 97

WHEN QUALITY IS YOUR TARGET...
THE GRIPWELL ELECTRONIC CHASSIS LATCH HELPS YOU HIT THE BULLSEYE


Red unlock indicator
Secondary extreme vibration lock
Proven Hartwell trigger action lock
20° free travel for gripping
Boss for optional bar handle
Permanent Gripwell handle
Keeper designed for easy seating
MINIATURE GRIPWELL
½" take-up • 8 to 1 mechanical advantage

GRIPWELL® ELECTRONIC CHASSIS LATCH

A handsome, strong and durable handle latch to fasten "plug-in" type electronic chassis, providing for positive ejection and injection of the chassis and allowing an eight to one mechanical advantage, with a total one-half inch take up.

Write today for complete information

THE HARTWELL CORPORATION
9035 VENICE BOULEVARD, LOS ANGELES 34, CALIFORNIA
Offices: Chicago • Ft. Worth • Hackensack • Seattle • Wichita

Circle F-40 on Page 97

NEED INFORMATION ON COMMERCIALLY AVAILABLE INDUSTRIAL FASTENERS?

Use a READER SERVICE CARD

page 97

Simply circle the Item Numbers relating to the advertised products you're interested in; fill in your name, title and company address; and drop it in the mail. (It's already addressed to us and the postage is paid.)

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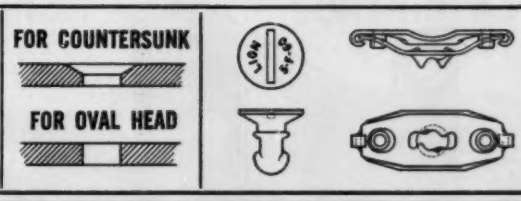
A PENTON PUBLICATION CLEVELAND 13, OHIO

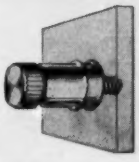
Captive Quick-Opening Fasteners:

Southco standards provide many benefits at low cost for access through doors, covers, panels and into drawers

LION ¼ TURN FASTENERS

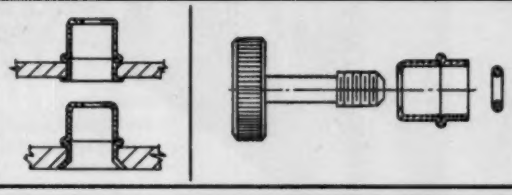
Quick, positive locking, by fractional turn. Tight seal formed by compression of leaf spring. Alignment and stack height not critical. Approved for aircraft use. Rugged. Extra strength provided by swaged nose. Vibration resistant.





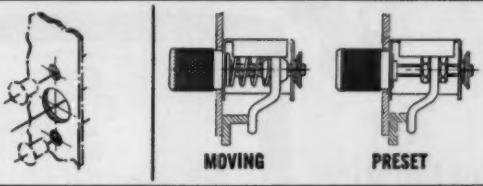
RETRACTABLE SCREW FASTENERS

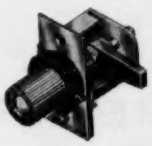
Stand-off thumb screws from stock to eliminate costly, special fasteners. Installed quickly without special tools. Accommodate misalignment. Complete range of standard sizes.



ADJUSTABLE PAWL FASTENERS

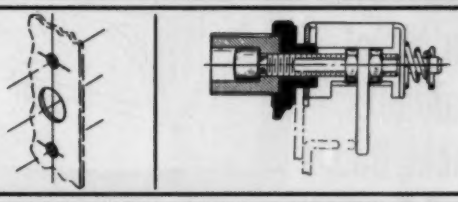
Pre-assembled, quickly installed. Accommodate variations in frame thickness up to ½ inch. One-quarter turn closes, additional turns increase grip pressure. Attractive appearance, long life. Moving or pre-set pawl. Miniature, intermediate and large sizes.





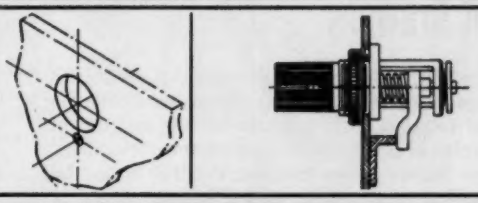
ADJUSTABLE PAWL FASTENER

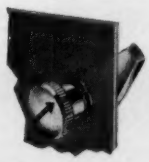
Has twin-knob control. One knob controls pawl, pointer shows pawl position. Other knob controls amount of pressure to seal closure with uniform pre-set compression. Easily installed.



ADJUSTABLE PAWL FASTENER

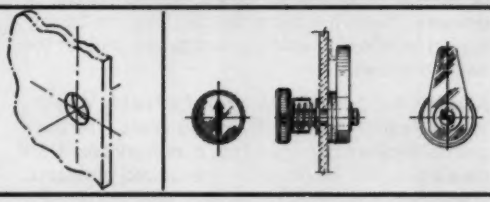
Compact and rugged. Eliminates rivets or bolts to save installation time. Three types cover grip range up to ¾". Supplied either with integral metal and plastic knob, plastic knob or for your knob.





ARROWHEAD DOOR LATCH

Requires only one hole to install. Operates on quarter turn. Holds under spring tension. Arrow shows pawl position; no pawl stops required. Uses minimum inside space.



Free Fastener Handbook

Send for your complete Southco Fastener Handbook, just printed. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS

LION

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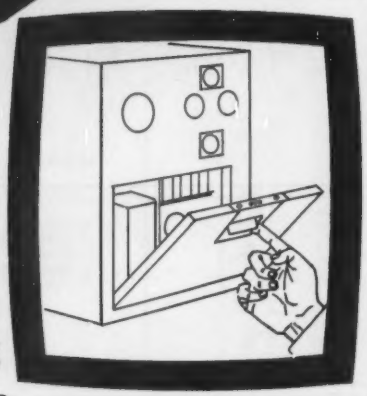
ADAMS-RITE FLUSH TYPE LATCHES

Other models available with or without key-operated cylinder lock



For Installation in Metal Cabinets, Panels, Doors and Drawers

ADAMS-RITE offers a complete line of flush latches designed for attractive, functional installation in metal cabinets such as computer and instrument consoles and electronic equipment enclosures. These latches can be mounted in either horizontal or vertical positions, on doors, hinged panels, or drawers. The bolt is retracted by lifting the spring-loaded handle-flap which also acts as a pull for the panel or drawer.

ADAMS-RITE has been manufacturing quality mechanical hardware for over 50 years. The company's engineering staff has a proven talent for developing new solutions to specialized problems. If you have a particular locking or latching requirement, A-R will design and manufacture to your specifications.

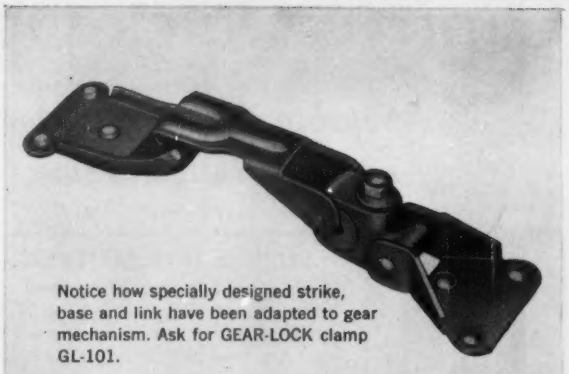
Write for complete information or latest file catalog of descriptive literature. Dept. C-1-1

a r ®

"Over half a century"

ADAMS-RITE
MANUFACTURING COMPANY
540 West Chevy Chase Drive
Glendale 4, California

Circle F-42 on Page 97



Notice how specially designed strike, base and link have been adapted to gear mechanism. Ask for GEAR-LOCK clamp GL-101.

For mounting on flat surfaces. Ask for Hook type clamp HR-1.

CHOOSE FROM THE LINE THAT GIVES YOU MORE TO START WITH!

With more to choose from, you'll probably find just what you *need* to start with. The Bassick line of clamps and fasteners includes hook, loop, hinge, springloaded and gear-lock types as well as many special duty clamps.

The *real* beauty of the Bassick line is its unusual flexibility. We frequently adapt one of our many standard clamps or the component parts to *solve* specific customer problems—save money and time. Send for catalog: Bassick Clamps and Fasteners. It may well help obtain better fastening for *your* containers.

THE BASSICK COMPANY, Bridgeport 5, Conn. *In Canada:* Belleville, Ont. O.14

Symbol of SW Excellence
Bassick
A DIVISION OF
STEWART-WARNER CORPORATION

Circle F-43 on Page 97

NEW

COMPRESSION CATCHES
ADJUSTABLE CATCHES
HANDLES (all to Armed Forces qualifications)

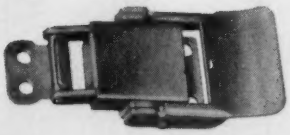
FOR INSTRUMENT CASES • TRANSIT CASES • CONTAINERS

No. VHC 340-2
(actual size)

A WIDE RANGE of STYLES and SIZES from junior..... to GIANT

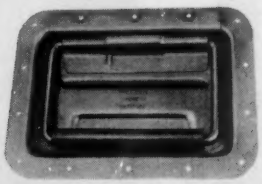
COMPRESSION SPRING CATCHES, No. 340 series, are miniature in size. Preloaded to 12 lbs. Standard 18 lb. holding tension. Cold rolled steel, plated or finished to specifications, or stainless steel. Styles with lever straight, as illustrated, or with up-sweep or down-sweep.

ADJUSTABLE CATCHES for varied applications (also recessed), No. 250 series, provide secure holding, easy engagement, rapid release. Steel or aluminum base. Designed to function up to 1,000 lbs. (manual operation). Stress strength to 3,000 lbs. (steel base). Styles for surface mounting or recessed in a plate. Hole for wire seal and slot for 3/8" "Navy" seal.



COMPRESSION SPRING DRAW PULL CATCH No. SC-B-83314-42 with springs concealed. Provides 70 lbs. holding tension on standard specification.

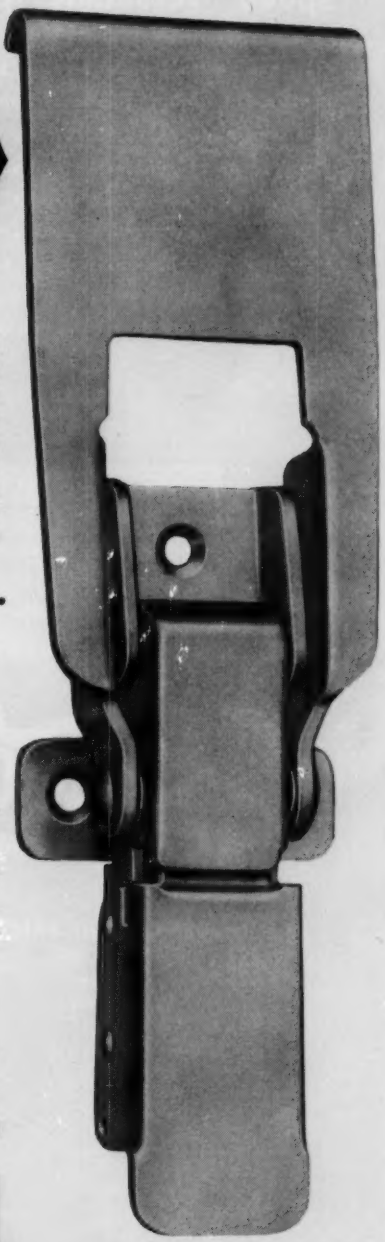
HEAVY-DUTY PULL-DOWN CATCH No. HC201 with holes for fastening or for welding applications. Available in plated finishes; also of brass, stainless steel, or aluminum materials.



RECESSED HANDLE No. H560 available in steel or aluminum.

SURFACE HANDLE No. H945 to meet Armed Forces Specification MIL-T-945.

A VARIED LINE OF CATCHES AND HANDLES to meet commercial requirements. Descriptive literature on request. Inquiries invited on design and application problems.



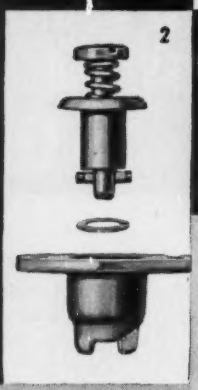
No. VHC 250-65
(actual size)

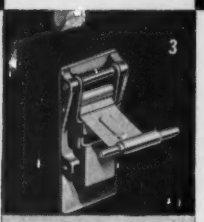
NIELSEN HARDWARE CORPORATION
770 WETHERSFIELD AVE., HARTFORD 1, CONN.

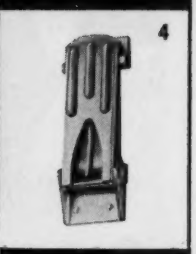
specialists in fasteners for industry

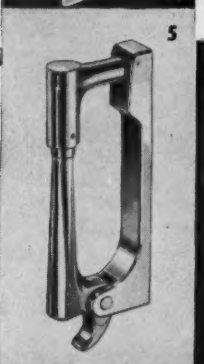
speed · versatility · positive performance

Outstanding creative engineering at Camloc has produced a variety of fastening devices. For access panels, doors, other closures, for simplified replacement of components and sub-assemblies. There are other fastening devices, designed for a variety of specialized applications, all of them retaining the three important features that characterize all Camloc products . . . speed, versatility and positive performance.



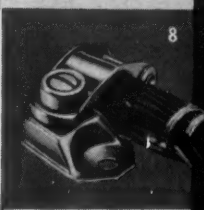




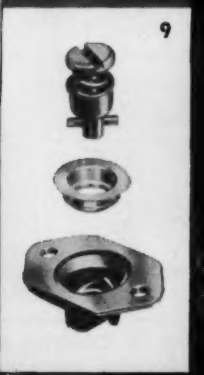


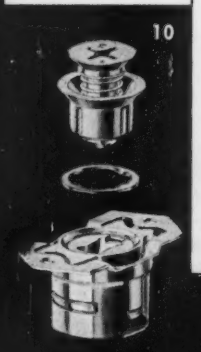
1. 5F fastener for thin materials
2. 2600 Series Quarter-Turn
3. Miniature Toggle Tension Latch
4. 46L Container Latch
5. Electronic Chassis Latch
6. 37L Heavy Duty Container Latch
7. 28F Series Quarter-Turn
8. 7C Harness Clamp
9. 4002 Series Quarter-Turn
10. SPF (Stressed Panel Fastener)

CAMLOC®



JUST OFF THE PRESS
Catalog No. 60
Write for your
free copy now.





CAMLOC FASTENER CORPORATION · 22 SPRING VALLEY RD., PARAMUS, N. J. · LOS ANGELES, CALIF. · FT. WORTH, TEXAS

CHAPTER
25

Retaining Rings

BASIC function of retaining or snap rings is to provide a shoulder for retaining, locking, or positioning components on shaft, stud, or pin members, and in housing bores. Retaining rings presented here are, in general, representative of types presently available.

Circolox Retaining Rings

Form: Stamped metal retaining rings. Rings are mounted in annular groove in shaft or housing bore.

Design Features: Designed to maintain circularity and constant gripping pressure in mounting groove. Can be reused without loss of spring action. Lug construction at ends of rings facilitates assembly and removal.

Materials: Carbon spring steel, stainless steel, beryllium copper, and phosphor bronze.

Sizes: 1/8 to 2 1/2 in. nominal shaft and housing diameters.

Source: Ramsey Corp., subsidiary of Thompson Ramo Wooldridge Inc., St. Louis, Mo.

(See Ad, Page 170)

Industrial Retaining Rings

Form: Stamped metal retaining rings. Rings are mounted in annular groove in shaft or housing bore.

Design Features: Provides low-cost shoulder for locking and positioning components on shafts and in housing bores. Designed to maintain circularity and constant gripping pressure in mounting groove. Can be reused without loss of resiliency. Open and crescent type external rings for radial mounting on shafts can be adapted to high-production assembly techniques.

Materials: Carbon spring steel, stainless steel, phosphor bronze, and berryllium copper.

Sizes: 0.040 to 2.5 in. nominal shaft diameters; 0.250 to 2.5 in. nominal bore diameters.

Source: Industrial Retaining Ring Co., Irvington, N. J.

(See Ad, Page 172)

National Retaining Rings

Form: Split, one-turn, formed retaining ring. Ring is mounted in annular groove in shaft or housing bore.

Design Features: Eliminates need for machining or grinding of shaft stock to form shoulders. Simplifies assembly of components on shafts and pins or in housing bores.

Materials: Heat-treated carbon spring steel.

Sizes: 3/16 to 3-in. shaft diameters.

Source: The National Lock Washer Co., Newark, N. J.

Peck Spring Clips

Form: Precision-formed wire "hairpin" shaft clips. Clips snap into annular groove on shaft or pin with ends projecting beyond shaft surface.

Design Features: Will rotate within specified circumference. Can be applied or removed with pliers. Used to fasten rotating or nonrotating parts on small shafts in office equipment, instruments, etc.

Materials: All types and analyses of wire materials.

Sizes: 1/16 to 1 in. shaft diameters.

Source: The Peck Spring Co., Plainville, Conn.

Plasti-Ring

Form: Plastic ring or circular cross-section. Rolled into annular groove on shaft or pin, ring partially projects above surface.

Design Features: Provides low-cost, lightweight shoulder for small machine shafts. Resists vibration, friction and wear, and can withstand up to 250 pounds direct shear force.

Materials: White vinyl plastic.

Sizes: 1/8 to 1-in. shaft diameters.

Source: Fastex Div. of Illinois Tool Works, Des Plaines, Ill.

Reliance Snap Rings

Form: Split, one-turn, uniform section retaining ring formed from hard drawn or annealed wire. Ring is mounted in annular groove in shaft or housing bore.

Design Features: Provides a tight groove fit at assembly. For shoulder applications, ring is designed to withstand predetermined thrust load. Annealed wire rings are formed in open position and butted when squeezed or closed into place.

Materials: Spring steel and low-carbon steel.

Sizes: 1/8 to 9.4488 in. shaft diameters; 0.375 to 10.000 in. bore diameters. Ring types include closed full, open clip, and bearing configurations.

Source: Reliance Div., Eaton Mfg. Co., Massillon, Ohio.

Rotor Clip

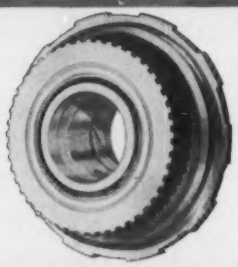
Form: Stamped metal retaining rings. Rings are mounted in annular groove in shaft or housing bore. Size is engraved on each ring.

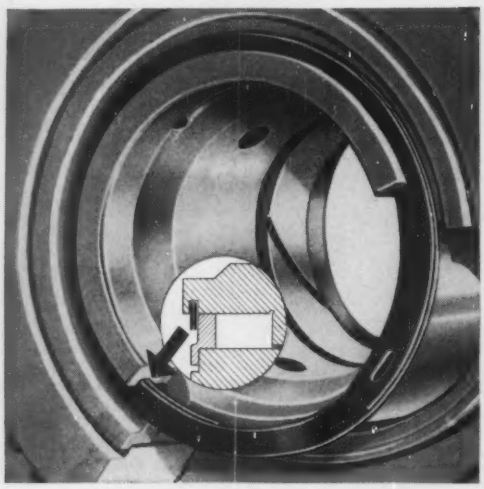
Design Features: Provides low-cost means of locking and positioning parts on shafts and in housing bores. Tapered design affords lower stress at the midsection. Adaptable to high-production assembly techniques. Engraving provides foolproof size identification.

Materials: Carbon spring steel, stainless steel, bronze, and beryllium copper.

Sizes: 0.040 to 2.50-in. shaft diameters, 0.250 to 3.75-in. bore diameters.

tOtal 2 gives you the Superior Solution!



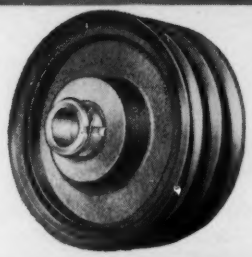


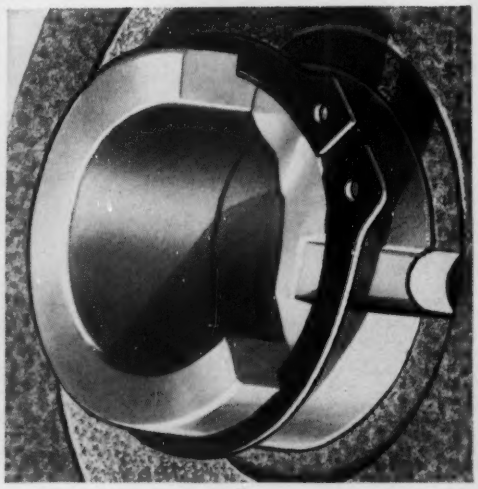
SpirOlox

was the Superior Solution to this application

This unique Ramco design, full-circle 360 degree retaining ring opens up unlimited possibilities for improved design and economies in thousands of new or present products. Check these outstanding features:

- √ Uniform wall allows installation with minimum clearance.
- √ Two turn, full-circle design eliminates gaps.
- √ No special tools needed for installation or removal.
- √ No tooling needed for prototypes.
- √ Develops "friction lock" under load.
- √ Single or multi-turn designs available.
- √ Always uniform in quality.
- √ Special designs for high-speed or tolerance stack-up problems.





CircOlox

was the Superior Solution to this application

This Ring provides the answer to easy, lightweight, low cost assemblies and reduced manufacturing costs. Made in a variety of types and sizes for the smaller shaft or housing diameters. Check these Circolox features:

- √ "Deep-groove" design permits maximum thrust with minimum weight.
- √ Easily installed or removed.
- √ Available in a variety of materials.
- √ Wide choice of finishes available.
- √ Always uniform in quality.
- √ Meet Government and Industry Standards.

Best proof that there are two sides to every story is contained in Ramsey's new tOtal 2 Retaining Ring Brochure. This novel two-sided Brochure shows you why it pays to have *both* modern types of retaining rings available to solve your particular problems... to give you the Superior Solution.

Ramsey's tOtal 2 gives you a choice of *both* modern types of retaining rings to help you increase product performance, improve appearance and reduce assembly costs. Ramsey is the only retaining ring manufacturer who can offer the advantages of the tOtal 2 retaining ring lines.

Your Ramsey Distributor will be glad to bring you *both* sides of the retaining ring story and show you how the tOtal 2 can give you the Superior Solution to your fastening problems. Use the coupon below to bring the new Ring Brochure and free copies of the new Retaining Ring Engineering Manual and complimentary subscription to our Technical Bulletin Service. Ask for free sample rings.

t2tal

IT TAKES 2 MODERN TYPES OF retaining rings TO SOLVE ALL YOUR PROBLEMS

manufactured by

RAMSEY CORPORATION

a subsidiary of

Thompson Ramo Wooldridge Inc. automotive group

RAMSEY CORPORATION

Box 513, Dept. B, St. Louis 66, Missouri

without cost or obligation, please

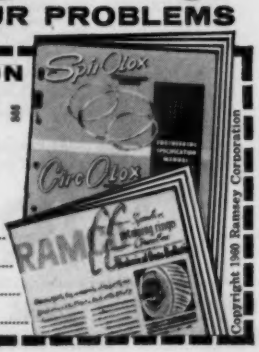
- ☐ Have my distributor bring Ring Brochure.
- ☐ Send Free Engineering Manual.
- ☐ Enter my name on complimentary subscription list for Technical Bulletins bringing the latest problem-solving ideas and applications.

Name..... Title.....

Company.....

Address.....

City..... Zone..... State.....



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Eliminate costly tooling and machining ...speed assembly...by using precision-made INDUSTRIAL Retaining Rings. Available for immediate delivery in types, finishes and sizes exactly right for your job.

Send for catalog and free samples.

- SERIES 1000—External Rings*
- SERIES 2000—External Rings*
- SERIES 3000—Internal Rings
- SERIES 3100—External Rings

**Also available stacked for speedier application.*

All series except 2000 available bowed for resilient take-up of end play.

IRR

Originators of modern retaining ring dispensing.

INDUSTRIAL RETAINING RING CO.

57 CORDIER ST., IRVINGTON 11, N. J. MD9

Circle F-46 on Page 97

Source: Rotor Clip Co., Farmingdale, N. Y.

Spirolox Retaining Rings

Form: Single or double-turn, flat, formed retaining rings. Rings are installed in annular groove in shaft or housing bore.

Design Features: Can be installed or removed without special tools. Performance of ring does not depend on inherent gripping power against bottom of grooves. Locks automatically in groove under thrust. Does not lose circularity or holding power on removal and can be reused. Single-turn ring is suited for light-duty applications and can be readily adapted to automatic assembly methods. Double-turn ring is for general-purpose application.

Materials: Spring steel, Type 320 stainless steel.

Sizes: ½ to 11 in. nominal shaft and housing diameters.

Source: Ramsey Corp., Subsidiary of Thompson Ramo Wooldridge, Inc., St. Louis, Mo.

(See Ad, Page 170)

Springrip Washer

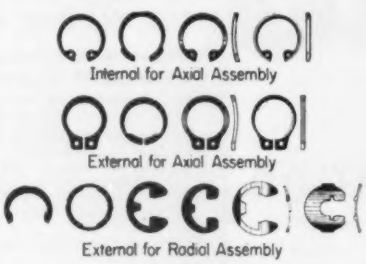
Form: Dished metal washer with teeth on inside diameter. Washer locks in place when pushed onto a stud, pin, or shaft.

Design Features: When washer is pushed into position on stud or shaft, teeth engage surface around full circumference to achieve high locking power. Used to fasten rotating or nonrotating parts to shafts, axles, or studs of steel, aluminum, zinc, magnesium, and plastic.

Materials: Heat-treated high-carbon steel.

Sizes: 3/32 to 1-in. nominal diameters. Body styles include internal type for use in drilled or bored holes.

Source: Fastex Div. of Illinois Tool Works, Des Plaines, Ill.



Truarc Retaining Rings

Form: Stamped metal retaining rings. Rings are installed in annular groove. Internal types are used in bores or housings, external types on shafts and similar parts.

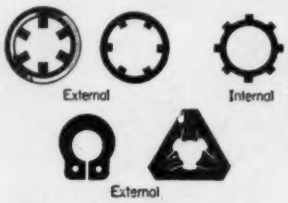
Design Features: Will withstand heavy thrust loads, impacts, and vibrations. Bowed and beveled types provide end-play take-up. Lugs at end of rings facilitate assembly and removal. Axial types usually handled with pliers, radial types with screwdriver or simple hand tools. Some of smaller rings can be adapted to high-speed, production-assembly methods.

Materials: Carbon spring steel, beryllium copper, aluminum, phosphor bronze, stainless steels.

Sizes: 0.040 to 10-in. nominal shaft diameters; 0.250 to 10-in. nominal bore or housing diameters.

Source: Waldes Kohinoor, Inc., Long Island City, N. Y.

(See Ad, Page 173)



Truarc Self-Locking Rings

Form: Stamped-metal retaining rings. Internal type installed in ungrooved bores and housings; external type on ungrooved shafts, studs, pins, bosses. Rings grip surface under spring tension to lock ring in place.

Design Features: Will withstand moderate thrust, impact, or vibrational loads. Can be installed in shallow groove to increase holding power. Rings accommodate large diameter tolerances, from ±0.003 to ±0.005 in. for some external types. Can be positioned at any point in bore or on shaft, automatically compensating for tolerances in retained parts.

Materials: Carbon spring steel, beryllium copper, phosphor bronze, stainless steel.

Sizes: 0.062 to 1-in. nominal shaft diameters; 0.312 to 2-in. nominal bore diameters.

Source: Waldes Kohinoor, Inc., Long Island City, N. Y.

(See Ad, Page 173)

X-Washer

Form: Split, one-piece washer with projecting ears. Washer is clamped in place in annular groove on pin.

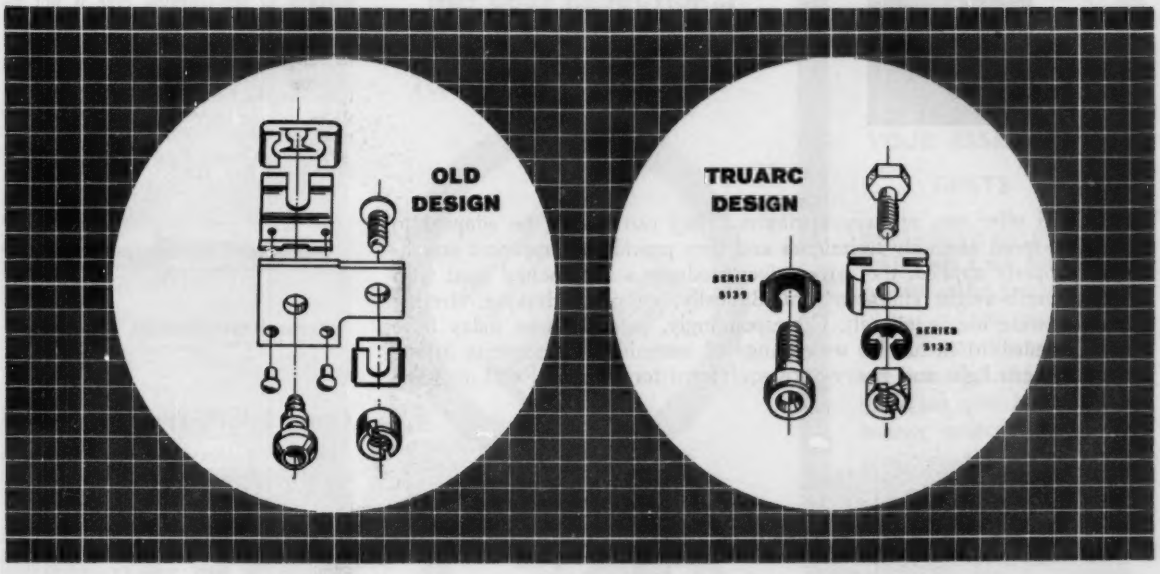
Design Features: Can be readily installed by hand or with pliers. Closure is positive over 360 degrees. Permits quick disassembly. Used as locking shoulder on pins or small shafts.

Materials: Cold-rolled steel.

Sizes: 0.085 to ¼-in. nominal pin diameters.

Source: Standard Locknut and Lockwasher Inc., Indianapolis, Ind.

How Truarc rings simplified design and saved $60 per 1000 units



Look behind this big saving in parts on the auto contact points made by Shurhit Products Inc., Waukegan, Illinois. One Truarc Ring replaced an expensive special purpose fastener. Another eliminated a clip and retaining plate which were 4 times more expensive and difficult to assemble. A third replaced a special purpose nut.

Equally important, besides simplifying and improving design, Shurhit reduced the over-all size of its auto points by ¼" and reduced assembly time by 50%. *Savings: $60 per 1000 units.* Let Truarc Rings help cut your basic manufacturing cost by simplifying design and making assembly faster and easier. Rings often contribute highly saleable compactness as well!

WHY TRUARC RINGS BELONG ON YOUR PRODUCT

They offer a simple and effective way to locate, retain or lock components in place. They fit into grooves inside bores and housings. They work as effectively on shafts or studs (some without grooves).

More than a fastener! Truarc Rings act as a component by replacing machined shoulders, threaded fasteners, rivets and other fastening devices. What's more, they often eliminate threading, tapping, drilling and other machining operations. **Available in 50 types** (some with up to 98 sizes), in 6 metals, and 13 finishes—Truarc Retaining Rings can be conveniently ordered from more than 100 stocking points throughout the U. S. A. and Canada.

Read about the impact of Truarc Rings on more than 70 different designs (your product type may be among them) in our Catalog RR 10-58. For *immediate* action call your nearest **Authorized Truarc Distributor.** Look under "Rings, Retaining" in the Classified Telephone Directory. O-1

WALDES TRUARC® RETAINING RINGS

WALDES KOHINOOR, INC.,
47-16 Austel Place, Long Island City 1, N. Y.

9 OUT OF 10 PRODUCTS CAN BE IMPROVED WITH TRUARC RETAINING RINGS

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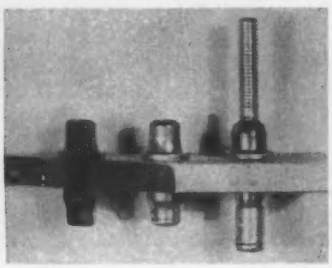
PRODUCT

DIRECTORY

CHAPTER

26 Rivets

RIVETS offer two primary attributes. They can readily be adapted to high-speed assembly techniques and they provide a permanent attachment. Properly applied, the driven rivet produces a neat, sound joint with high strength-weight characteristics. Basically, an old technique, riveting has seen wide use in aircraft. Correspondingly, potential uses today have been extended to include a wide range of assembly requirements in the design of both light and heavy-duty equipment for industrial and domestic service.



Blind Huckbolt Fastener

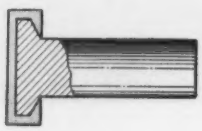
Form: Five-piece, blind-fastener assembly consisting of preassembled pin, expansion sleeve, filler sleeve, washer, and locking collar. In assembly, filler sleeve is pushed into blind expansion sleeve. Continued pull by pulling tool draws expansion sleeve over tapered end of filler sleeve to form bulbed blind head. At the same time, collar is swaged into locking grooves on other side of joint to lock assembly. Tail of pin breaks off automatically when fastener is completely driven.

Design Features: Provides permanent, rigid fastener with high shear, tension, and fatigue strengths. Requires accessibility of work from one side only.

Materials: Pin is heat-treated alloy steel, blind expansion sleeve is annealed steel, filler sleeve is heat-treated steel, and collar and washer are mild steel.

Sizes: 1/4 and 5/16-in. nominal diameters. Various grip lengths.

Source: Huck Mfg. Co., Detroit, Mich.



Caplet

Form: One-piece, solid, metal rivet in which the standard Coopers' belt rivet head has been covered with plastic insulation.

Design Features: Insulated head provides electrical insulation for over 5000 v. Driven rivet provides secure joint. Applications include use in electrical and electronic equipment requiring insulation of fastener from components, as actuator knobs used on relays and switches, and for "feet" on desk equipment and appliances.

Materials: Rivet is made with aluminum, brass, and steel shanks. Insulation layer is Cycolac.

Sizes: 1/16, 3/32, and 1/8-in. shank diameters; shank length in multiples of 1/32 in.

Source: Pylon Co. Inc., Attleboro, Mass.

Cherry Pull-Thru Rivet

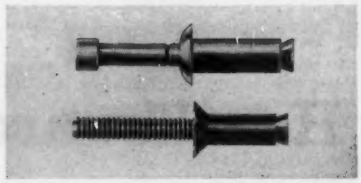
Form: Two-piece, tubular blind rivet consisting of a preassembled hollow rivet on a pull stem. Rivet is set by pulling stem through rivet shank. Upsetting head on end of stem forms "tulip head" in blind end of rivet. When blind head is tightly formed against part, upsetting head partially collapses and continues through rivet, expanding shank.

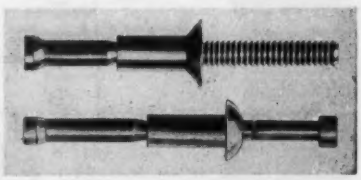
Design Features: Provides positive shank expansion. Clinch is comparable to solid rivet. Material spoilage is reduced, since clinching is by a pulling action. Pulling head of rivet tool does not come in contact with assembly parts and will not mar surfaces or shatter brittle materials. Rivet hole can be filled with an umbrella or plain plug where closed assembly is required. Used for rapid assembly in blind or open locations where high shear strength of self-plugging type is not required.

Materials: Aluminum, mild steel, or Monel.

Sizes: 1/8 to 9/32-in. nominal diameters. Grip lengths from 1/16 to 3/4-in. Head styles include universal, countersunk, and modified truss.

Source: Cherry Rivet Div., Townsend Co., Santa Ana, Calif.





Cherry Self-Plugging Rivet

Form: Two-piece, tubular blind rivet consisting of preassembled hollow rivet on pull stem. Enlarged portion of stem is first pulled into rivet, expanding shank to fill hole. Conical tip on stem then upsets blind head. Continued pull fractures stem, leaving rivet with protruding end which is trimmed flush to rivet head with hand or power trimmers.

Design Features: Driven rivet has properties closely similar to those of solid rivet. Material spoilage is reduced since clinching is by pulling action. Pulling head of rivet-tool does not come in contact with assembly parts and will not mar surfaces or shatter brittle materials. In use, rivet pulls up tight, resists vibration, and provides tamper-proof fastening. Used for rapid assembly in blind or open locations where high shear strength is required.

Materials: Aluminum, mild steel, or Monel.

Sizes: 1/8 to 9/32-in. nominal diameters. Grip lengths from 1/16 to 3/4-in. Head styles include universal, countersunk, and modified truss.

Source: Cherry Rivet Div., Townsend Co., Santa Ana, Calif.

Cherrylock Rivet

Form: Three-piece, tubular, blind rivet consisting of preassembled hollow rivet and positive mechanical-locking ring on pull stem. Enlarged end of stem is pulled into rivet, upsetting blind head to draw parts up tight and to seat rivet firmly. Plugging portion of stem expands rivet sleeve to fill hole and reduces in diameter as it passes through sleeve. When groove in stem and countersink in

WHEN YOU NEED TUBULAR RIVETS

Milford's five manufacturing plants are within overnight trucking distance of your assembly line

NEW ENGLAND DIVISION
Milford, Connecticut (Trinity 8-4631)

PENN DIVISION
Hatboro, Pennsylvania (Osborn 5-4560)

OHIO DIVISION
Elyria, Ohio (Fairfax 3-3177)

ILLINOIS DIVISION
Aurora, Illinois (Twinoaks 2-4278)

PACIFIC DIVISION
Norwalk, California (Oxbowl 3-3777)

Rivets can create "king-size" headaches when they aren't at your assembly line in the quantity you need—when you need them.

To give you unmatched delivery service on tubular rivets, Milford has five manufacturing plants and twenty sales offices strategically located across the country's industrial beltline. To cut delivery time and production costs, to improve product appearance, to assemble your product on automatic rivet-setting machines—get in touch with Milford.

COST PREVENTION... NOT COST REDUCTION... IS THE EFFICIENT WAY TO LOW-COST ASSEMBLY

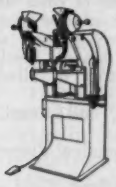
The 'in-place' cost of a fastener is what really counts to cost-conscious production men. By deciding on inexpensive Milford tubular rivets as a fastening method and installing them with Milford automatic rivet-setting machines, design and production engineers are eliminating costs at the initial production stage rather than trying to reduce costs later at the assembly line. Write for more information.

Model 423

Model 250

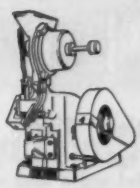
MILFORD'S FLEXIBLE RIVETER LINE CAN HELP CUT YOUR ASSEMBLY COSTS

Milford adapts to your production line with a wide range of automatic riveters designed to cut assembly costs. Count on Milford's versatility to come up with answers you need at substantial cost savings over other fastening methods. Write for more information.



Model 72

Model 53



Model 52-S-55

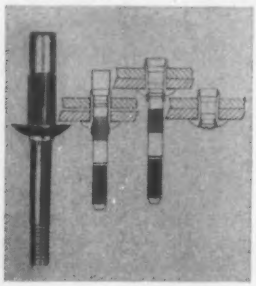
Model 56

THE MILFORD RIVET

MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNSYLVANIA • ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

Circle F-47 on Page 97



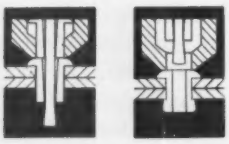
rivet line up, pulling head shifts automatically, inserts locking ring, and fractures stem flush with rivet head.

Design Features: Provides hole fill even in oversize holes. Material spoilage is reduced since clinching is by pulling action. Used for rapid assembly in blind or open locations where high shear strength is required. Flush fracture eliminates necessity for trimming stem, reducing installation costs.

Materials: Aluminum, Monel, and A286 stainless steel.

Sizes: 1/8 to 1/4-in. nominal diameters. Grip lengths from 1/16 to 7/8 in. Head styles include universal and countersunk.

Source: Cherry Rivet Div., Townsend Co., Santa Ana, Calif.



Chobert Rivet

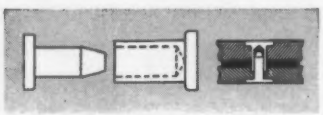
Form: Tubular blind rivet which is upset by drawing flared mandrel through tapered hole in shank.

Design Features: Mandrel is reused. Rivet setting can be manual, or automatic by hand gun or machine at rates up to 2000 per hr. Rivet hole can be plugged with sealing pin where greater shear strength or sealing are desired. Used for low or high-speed riveting in blind or open locations.

Materials: Aluminum, mild steel, or Monel.

Sizes: 3/32 to 1/2-in. nominal diameters. Various grip lengths.

Source: Avdel Inc., Burbank, Calif.



Compression (Cutlery) Rivet

Form: Two-piece rivet assembly consisting of a deep-drilled and a solid rivet. Deep-drilled rivet is inserted in counterbored hole and solid rivet is pressed into tubular shank. Diameters of solid shank and drilled hole are selected to develop a tight compression fit.

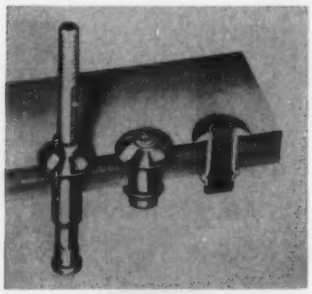
Design Features: Provides a low-cost, high production permanent fastener for light assemblies where a flush surface fit is required. Heads of both rivets can readily be matched for appearance purposes. Assembly pressure can be controlled to prevent splitting of wood or plastic parts.

Materials: Steel, brass, aluminum or other materials.

Sizes: 0.172 and 0.216 nominal hole diameters. Various grip lengths. Head style is flat.

Source: Produced by several manufacturers. Information and illustration, courtesy The Tubular and Split Rivet Council, New York, N. Y.

(See Ads, Pages 175, 177, 179, 183, 185)



Conical Keystone Lock Rivet

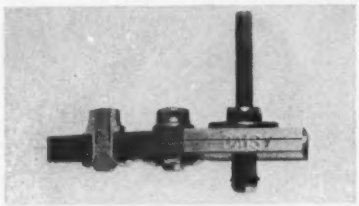
Form: Two-piece, tubular blind rivet consisting of preassembled sleeve and pin. In driving operation, sleeve is expanded by pin to fill hole. Sleeve end is upset into bulbed head and positive mechanical keystone lock is formed at rivet head. Tail of pin breaks off automatically when rivet is completely driven.

Design Features: Driven rivet is essentially mechanical equivalent of one-piece solid rivet of same material. Positive mechanical locking action prevents pin working free under vibration or fatigue loads. Bulb-forming operation causes assembly members to be tightly compressed and assures high strength and rigidity. Positive inspection of joint is possible from driving side. Particularly suited to high-speed automatic assembly operations in blind or open locations.

Materials: Aluminum.

Sizes: 1/8 to 13/64-in. nominal diameters. Various grip lengths. Head styles include protruding and countersunk.

Source: Huck Mfg. Co., Detroit, Mich.



Daisy Rivet

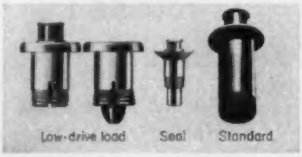
Form: Two-piece tubular blind rivet consisting of preassembled sleeve and pin. In driving operation, sleeve is split by head of pin to form five "petal" segments on blind side. Spring action of spreading segments draws assembly pieces together and locking collar, which is integral with sleeve head, is cold swaged into locking grooves in pin at point of maximum clamp tension. Tail of pin breaks off automatically when rivet is completely driven.

Design Features: Broad bearing area of blind head provides high resistance to tear-out or pull-through. Positive locking action holds pin securely in place. Provides high pull-together force. Particularly suited to high-speed assembly operations in blind or open locations.

Materials: Aluminum or mild steel.

Sizes: 1/4-in. nominal diameter. Various grip lengths.

Source: Huck Mfg. Co., Detroit, Mich.



Deutsch Drive-Pin Rivet

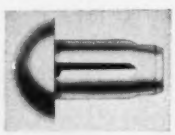
Form: Two-piece, tubular blind rivet consisting of preassembled pin and sleeve (formerly known as Barker blind rivet). Rivet is set by driving pin into tapered hole at blind end of sleeve to form blind head. When pin is of the headed type, lip section on driving end of sleeve is peened over after driving to lock pin in place. Low-driving-load rivet design uses pin with slightly oversize knurled-head section that seats and locks itself into the top of the sleeve when driven and does not require peening.

Design Features: Pin is driven from one side with hammer. Variable grip length. Provides high shear and tensile strength. Resists heat and corrosion and is light in weight. Rivet construction eliminates the need for inner-side spot facing. Particularly suited for use in buried-hole installations, double construction, or where a simple, strong, blind rivet is needed. Sealing-rivet design has integral cap that covers blind end of pin to provide positive, leaktight seal. Low-driving-load rivet reduces required setting force and can be used with thin, soft, or otherwise fragile sections.

Materials: Sleeve is Type 303 or 17-PH stainless steel, pin is Type 431 or 416 stainless steel.

Sizes: 1/8 to 1/2 in. diameters. Grip lengths from 0.085 to 1.437 in. Head styles include countersunk (flush) or protruding (brazier). Rivet types include standard, close-tolerance, high temperature-high strength, oversize, sealing, and low-driving-load designs.

Source: Deutsch Fastener Corp., Los Angeles, Calif.



Drive Studs

Form: Headed cylindrical pin with three longitudinal surface grooves in shank. When stud is driven into prepared hole, elastic deformation of grooves develops radial forces to lock shank in position.

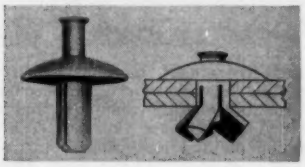
Design Features: Can be quickly installed with hammer blow. Resists vibration forces and can be removed easily without damage to assembly. Can be reused without appreciably affecting locking action. Used as headed fastener in blind or open locations to attach covers, name plates, conduit clamps, or spring assemblies to cast iron, steel, or other materials.

Material: Steel.

Sizes: 0.067 to 1/4-in. shank diameters.

Lengths from 1/8 to 3/4-in. Head styles include round, flat countersunk, flat truss, and shoulder. Body styles include an offset-ribbed version for severe vibration service.

Source: Driv-Lok Sales Corp., Sycamore, Ill.; Groov-Pin Corp., Ridgefield, N. J. Illustration, courtesy Groov-Pin Corp.



Drive-Tite

Form: Two-piece, tubular blind rivet consisting of preassembled grooved drive pin mounted in hole in head of rivet with slotted shank. Rivet is set by driving pin into shank to expand slotted-end segments.

Design Features: Rivet is readily installed from one side, using hammer. Expanded shank segments produce tight grip on assembly members. Head of pin fits flush with head of rivet. Suitable for application in blind or open locations where material is sufficiently rigid to withstand driving force required.

Materials: Rivet body is aluminum; pin is aluminum, carbon steel, or corrosion-resistant steel.

Size: 1/8 to 1/4-in. nominal diameters. Grip lengths from 1/16 to 1 in. Head styles include brazier, countersunk, and large modified truss.

Source: Olympic Screw & Rivet Corp., Downey, Calif.

(See Ad, Page 184)

Dupont Blind Expansion Rivet

Form: One-piece tubular rivet containing a chemical charge which runs length of shank. Application of heat to rivet head activates charge, setting rivet almost instantaneously.

Design Features: Simplify fabrication operation. Setting is always accomplished from head side, using an electrically heated setting iron or similar tool. Shank expands to fill hole completely, insuring tight contact throughout thickness of joint. Sealed type rivet, which has plugged end, will not deform opposite or adjacent members located close to charge end when expanded, and is practically "noiseless" when being set. Range of grip length variation for some rivets may run to 1/8-in. Suitable for use in blind or open locations, and where space limitations for rivet assembly are severe.

Materials: Aluminum, superalloy, nickel alloy, or brass.

Sizes: 3/32 to 1/4-in. nominal diameters. Various grip lengths. Body styles include sealed (noiseless) or regular open types with modified brazier or countersunk head construction.

Source: E. I. duPont de Nemours &

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The combination of Townsend tubular rivets and setting machines gives you a fast, economical assembly method for a variety of metals, plastics and fabrics. You will find that installed costs are lower than most other fasteners. Also the slight pressure required to install them prevents damage to soft and fragile material.

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Townsend tubular rivets are available in steel, brass, copper, aluminum and other special materials. Quick delivery is assured by manufacturing facilities and stocks maintained in strategic locations throughout the United States. For information write to Engineered Fasteners Division, P.O. Box 71-E, Ellwood City, Pa.

Send For Your Townsend Tubular Rivet Selection Chart

Townsend Company

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Engineered Fasteners Division

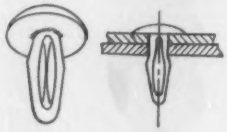
ELLWOOD CITY · PENNSYLVANIA

Cherry Rivet Division · Santa Ana, California

In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario

Circle F-48 on Page 97

Co. Inc., Explosives Dept., Wilmington, Del.



Fastex Drive Fastener

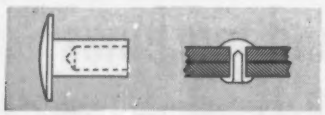
Form: One-piece, headed, plastic pin with enlarged shank section. Shank is pressed into prepared hole in panel. Bulbous section of shank expands after passing through panel to lock pin in place.

Design Features: Reusable. Can be installed with finger pressure or light tool. Provides a low-cost, rapidly assembled, headed fastener for light-duty service in blind or open locations. Can be used to retain two sheets, or to hold another member to a single sheet.

Material: Nylon.

Sizes: 0.136, 0.187, and 0.250 in. hole diameters.

Source: Fastex Div. of Illinois Tool Works, Des Plaines, Ill.



Full-Tubular Rivet

Form: One-piece metal rivet with a cavity extending almost full length of shank. Rivet is driven through material to be fastened and clinched with an anvil in rivet-setting machine.

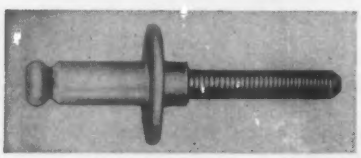
Design Features: Provides a low-cost, high-production permanent fastener for assembling materials such as leather, plastic sheet, wood, and fabric. Since rivet is self-piercing, need for separate hole-forming operation is eliminated. Can be used with a cap, which acts as a washer to prevent clinch from tearing material and improves appearance and strength.

Materials: Steel, aluminum, brass, copper, or iron.

Sizes: 9/64, 3/16-in. and other shank diameters. Various grip lengths. Head styles include oval, truss, countersunk, and flat.

Source: Produced by several manufacturers. Information and illustration, courtesy The Tubular and Split Rivet Council, New York, N. Y.

(See Ads, Pages 175, 177, 179, 183, 185)



Hi-Clinch

Form: Two-piece tubular blind rivet consisting of preassembled hollow rivet and headed pin. In driving operation, blind end of rivet shank is split by head of pin to form four radial segments on blind side. Clamping action of spreading segments draws joint members together. Tail of pin breaks off automatically when rivet is completely driven.

Design Features: Automatic clamping action of rivet provides high clinching force. Primarily suited for high-speed sheet-metal assembly in blind or open locations. Provides variable grip range and eliminates need for close assembly tolerances. Can be used in punched holes and will accommodate moderate hole misalignment. Requires minimum clearance on blind side for assembly. Develops shear and tension strengths, respectively, of 1000 and 750 lb in 3/16 in. size and 1700 and 1250 lb in 9/32 in. size.

Materials: Rivet is 5056 aluminum alloy; pin is 2017-T4 or 2024-T4 aluminum alloy.

Sizes: 3/16 and 9/32-in. nominal diameters. Grip lengths from 0.036 to 0.375-in. Head style is universal and protruding.

Source: Olympic Screw & Rivet Corp., Downey, Calif.

(See Ad, Page 184)

Hi-Shear Rivet

Form: Two piece, solid rivet assembly consisting of hard, heat-treated, headed pin, and softer, malleable metal collar. End of pin shank has narrowed section. Pin is placed in hole and collar is formed over narrowed section of shank by special gun or tool that draws parts tightly together.

Design Features: Combines drivability of "soft" metal and shear strength of cold steel rivets with no loss in holding power. Can accommodate grip length variations up to 1/16-in.; surplus collar material is automatically trimmed when rivet is set. Used where a solid rivet is required with shear strengths in excess of those normally possible with standard rivets.

Materials: Pin is heat-treated alloy steel, corrosion-resistant steel, aluminum, titanium, or Haynes 25; collar is aluminum, low-carbon steel, corrosion-resistant steel, or Monel.

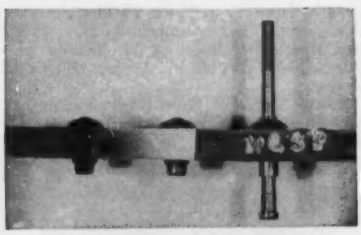
Sizes: 1/8 to 5/8-in. nominal diameters. Grip lengths 3/16 to 2-1/2-in. Head styles include flat, countersunk, and others.

Source: Voi-Shan Mfg. Co., Div. of Voi-Shan Industries, Inc., Culver City, Calif.

Huck Mechanical Lock Spindle Blind Rivet

Form: Three-piece (stainless steel) or two-piece (aluminum) tubular blind rivet, consisting of preassembled sleeve and pin. Locking collar is integral with sleeve in aluminum design, separate in stainless steel design. In driving operation, sleeve is expanded by pin to fill hole. Sleeve end is upset into bulbed head and positive mechanical locking collar is forced into conical recess between rivet head and pin. Tail of pin breaks off automatically when rivet is completely driven.

Design Features: Driven rivet is essentially mechanical equivalent of one piece solid rivet of same material. Positive mechanical locking action prevents pin

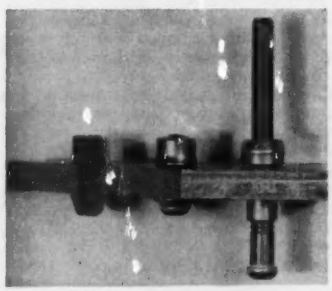


working free under vibration or fatigue loads. Bulbing operation causes assembly members to be tightly compressed and assures high strength and rigidity. Positive inspection of joint is possible from driving side.

Materials: In three-piece design, pin and sleeve are A-286 stainless steel, or pin is 17-4-PH stainless steel, sleeve and locking collar are Monel. In two-piece design, pin and sleeve are aluminum.

Sizes: 1/8, 5/32, and 3/16-in. nominal diameters. Various grip lengths. Head styles include protruding and countersunk.

Source: Huck Mfg. Co., Detroit, Mich.



Huck OS Structural Rivet

Form: Two-piece tubular blind rivet consisting of preassembled sleeve and pin. Sleeve contains integral locking collar head. During installation, sleeve is expanded by pin to fill hole. Sleeve end is upset to form bulbed blind head and collar is swaged into locking grooves to lock the assembly. Tail of pin breaks off automatically when rivet is completely driven.

Design Features: Provides permanent, rigid fastener. Has high shear strength, clinch, and tensile preload. Hole-filling qualities provide good sealing characteristics. Can be used metal-to-metal or with plastics and other nonmetallic materials.

Materials: Aluminum.

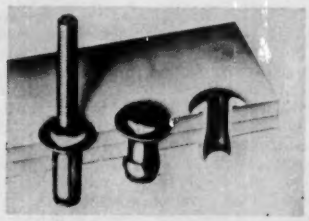
Sizes: 1/4, 5/16 and 3/8-in. nominal diameters. Various grip lengths.

Source: Huck Mfg. Co., Detroit, Mich.

Huck Pull-Through Rivet

Form: Two-piece, tubular blind rivet consisting of preassembled hollow rivet and cup-headed pin with pull grooves. Rivet is set by pulling pin through hole, forming blind head first and then expanding shank to fill hole.

Design Features: Provides low-cost blind rivet with good shear and tensile-strength properties. Driven rivet fills hole and has good assembly pull-together characteristics. Suitable for rapid assembly in blind or open locations. Typical uses include joining hollow tubing to fabricated parts and

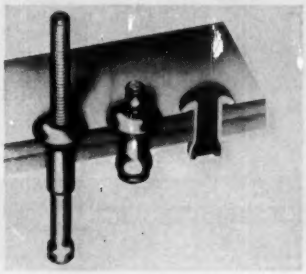


attaching electronic parts to chassis in difficult locations.

Materials: Steel or aluminum.

Sizes: ⅛ to ¼-in. nominal diameters. Various grip lengths. Head styles include brazier, truss, and countersunk.

Source: Huck Mfg. Co., Detroit, Mich.



Huck Self-Plugging Rivet

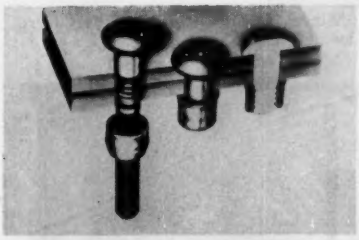
Form: Two-piece tubular blind rivet consisting of preassembled hollow rivet and headed pin with pull grooves. When driven, pin forms blind head and pin shank expands rivet to fill hole. Further driving breaks off tail of pin.

Design Features: Low-cost blind rivet with large grip range. Driven rivet has approximately strength of equivalent solid aluminum or steel rivet. Provides rapid assembly in blind or open locations.

Materials: Aluminum or mild steel.

Sizes: ⅛ to ¼-in. nominal diameters. Various grip lengths. Head styles include protruding, truss, and countersunk.

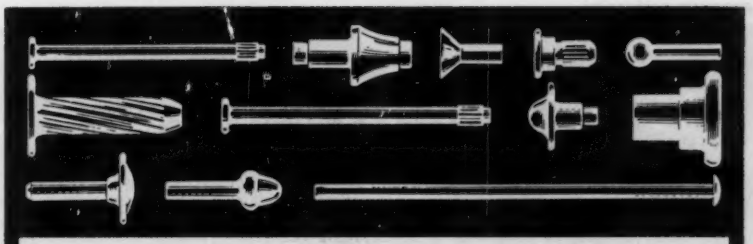
Source: Huck Mfg. Co., Detroit, Mich.



Huckbolt Fastener

Form: Two-piece fastener assembly with features of both bolt and rivet. It consists of headed, grooved pin and locking collar that is swaged into grooves to lock the assembly. In assembly operation, pin is inserted from one side and collar slipped on from other. Jaws of pulling tool grip pull-grooves on pin, developing necessary tension to pull assembly pieces together. Collar is then swaged in locked position and continued pull by tool jaws separates pin tail at end of locking grooves.

Design Features: Provides permanent, rigid fastener that is resistant to vibration. Can be readily adapted to high-speed pro-



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Circle F-50 on Page 97

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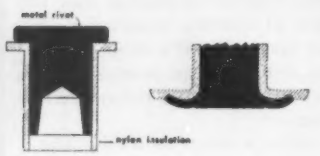
Circle F-51 on Page 97

duction methods. Has high shear, tension, and fatigue strengths. Can be employed on curved or slanted surfaces. Provides hole filling when desired and develops effective seal. Pulls assembly pieces together, eliminating need for accurate prefitting and assuring uniform tightening.

Materials: Pins are mild steel, medium carbon steel, heat-treated alloy steel, stainless steel, or aluminum; collars are mild steel, stainless steel, or aluminum.

Sizes: 5/32 to ¾-in. nominal diameters. Various grip lengths. Modified design for inaccessible locations include a stump version and a threaded pintail for manual wrench installation with special tool. Head styles include brazier, button, protruding, truss, flat, and countersunk.

Source: Huck Mfg. Co., Detroit, Mich.



Insulet Rivet

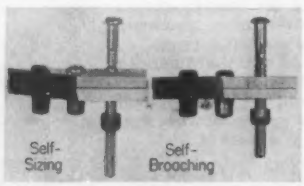
Form: Semitubular, flat-head, metal rivet in which shank section and under-the-head surfaces have been covered with a uniformly thick plastic insulation. When tubular shank of rivet is upset by conventional methods, plastic stretches and spreads out in uniform layer under metal.

Design Features: Driven rivet provides secure electrically insulated joint. Wall thickness of plastic insulation is 0.015 in. Primary use is in electrical assemblies to fasten two isolated electrical conductors to common insulated base or to attach insulated metal components to metal frame. Also used to rivet ceramics or glass (the plastic sheath acts as a shock absorber to prevent cracking) or to provide air-tight and water-tight assembly joints.

Materials: Rivet is aluminum, brass or steel; insulation layer is nylon.

Sizes: 3/32 to 3/16-in. nominal diameters. Shank lengths from ⅛ to ¼-in.

Source: Pylon Co. Inc., Attleboro, Mass.



Interference-Fit Huckbolt Fastener

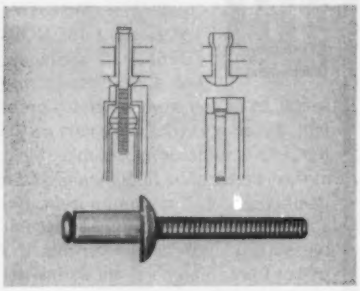
Form: Two-piece fastener assembly consisting of headed, grooved pin and locking collar that is swaged into grooves to lock the assembly. Pin contains an integral extruding land or progressive broach which automatically brings the hole to precise size during installation. In assembly operation, pin is inserted from one side. Jaws of pulling tool grip pull-grooves on pin. Hole is extruded or broached as pin is pulled through. Tool is released and collar is slipped over pintail. Tool is applied again. Continued pulling swages collar into locked position and separates pintail at end of locking grooves.

Design Features: Provides permanent, rigid fastener. Has high shear, tension, and fatigue strengths. Recommended for interference-fit applications with aluminum alloy components where fatigue strength, sealing, and structural rigidity are of primary concern.

Materials: AISI 4037 alloy steel.

Sizes: 3/16 and ¼-in. nominal diameters. Various grip lengths. Head styles are protruding and countersunk.

Source: Huck Mfg. Co., Detroit, Mich.



Olympic Pull-Through Rivet

Form: Two-piece, tubular blind rivet consisting of preassembled hollow, free-spinning rivet on pull stem. Rivet is set by pulling stem through hole in rivet. Enlarged upsetting head on stem forms blind head, clinches assembly members, and then collapses as it passes through rivet.

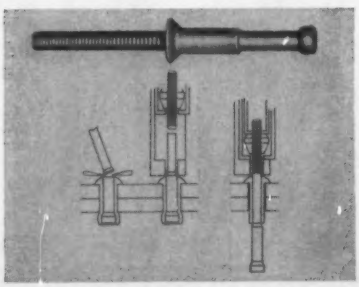
Design Features: Driven rivet is comparable to conventional hollow rivet in strength, configuration, permanence, and resistance to vibration. Provides high clinching action, and can be applied to highly finished surfaces without marring. Is self-aligning. Large shank expansion possible eliminates need for additional predrilling or reaming. Rivet can be plugged for strength, appearance, or other reasons. Designed for use where rivet is not highly stressed; provides rapid assembly in blind or open locations.

Materials: Aluminum, mild or alloy steel, or Monel.

Sizes: 3/32 to 9/32-in. nominal diameters. Grip lengths from 1/16 to 1¼ in. Head styles include universal, countersunk, flat, and modified truss.

Source: Olympic Screw & Rivet Corp., Downey, Calif.

(See Ad, Page 184)



Olympic Self-Plugging Rivet

Form: Two-piece, tubular blind rivet consisting of preassembled hollow, free-spinning rivet on pull stem. Rivet is set by pulling stem through hole in rivet. Enlarged plug section on stem expands and upsets hollow rivet shank forming barrel-shaped blind head. Under continued pull, stem breaks at preformed notch, releasing setting tool.

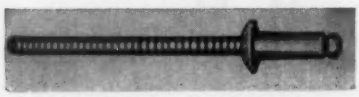
Design Features: Driven rivet is comparable to conventional solid rivet in strength, configuration, permanence, and resistance to vibration. Has low deflection factor for greater safety in highly stressed locations. Can be applied to highly finished surfaces without marring. Is self-aligning. Large shank expansion possible eliminates need for additional predrilling or reaming. Permits rapid assembly in blind or open locations.

Materials: Aluminum, mild or alloy steel, or Monel.

Sizes: 3/32 to 9/32-in. nominal diameters. Grip lengths from 1/16 to 1¼ in. Head styles include universal, countersunk, flat, and modified truss.

Source: Olympic Screw & Rivet Corp., Downey, Calif.

(See Ad, Page 184)



Oscar Rivet

Form: Two-piece blind rivet consisting of preassembled hollow rivet and headed pin. Rivet is set by pulling the pin. Enlarged head section on pin expands and upsets hollow rivet shank to form blind head. Under continued pull, pin breaks and comes free, leaving head in rivet.

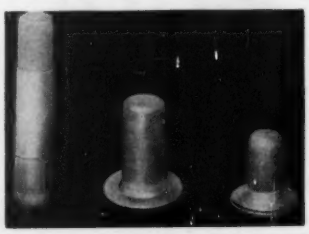
Design Features: High-production fastener with variable grip range. Primarily suited for high-speed metal fabrication in open or blind locations.

Materials: Rivet is 1100 or 5056 aluminum alloy, or carbon steel; pin is carbon steel or 2024 aluminum alloy.

Sizes: 3/32 to 3/16 in. nominal diameters. Grip lengths from 0.062 to 0.375-in., depending on rivet diameter. Head styles include protruding and 100-deg countersunk.

Source: Olympic Screw & Rivet Corp., Downey, Calif.

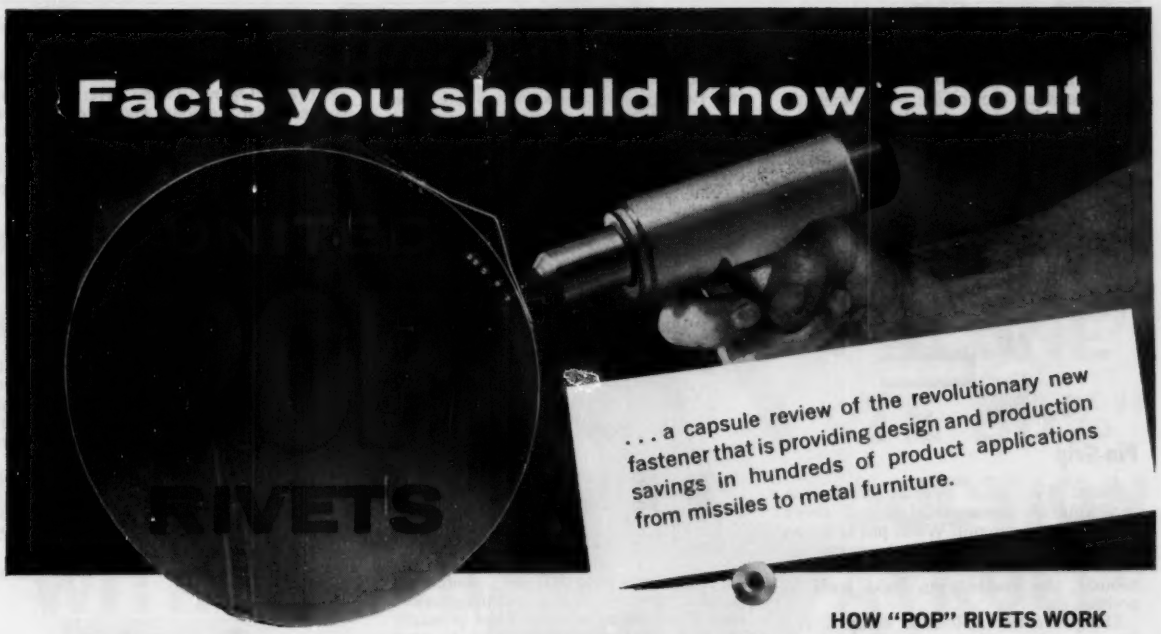
(See Ad, Page 184)



Pastushin Fluid-tight Slug Rivet

Form: One-piece headless rivet with aluminum-alloy sleeve on shank. Rivet is driven through material to be fastened. Alloy sleeve extrudes into leak areas between rivet and bore as rivet is driven. Countersunk hole in one fastened part provides space for upset of rivet to maintain flush head. Head and maximum flow of rivet shank material is obtained around flush head and upset end during driving.

Facts you should know about



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"POP" Rivets are high strength, precision-made hollow rivets assembled on a solid mandrel. Used in "blind" and "non-blind" applications. Made in a complete range of sizes and head styles in aluminum, monel, steel and copper. Available in both "Open-End" and "Closed-End" types.

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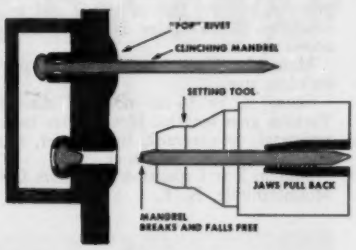
Lowest in cost and lightest in weight, these rivets are used for a wide variety of applications where a tight seal is not required. The open-end rivet is designed to have equal tensile and shear strength. Available in domed or countersunk heads.

HOW "POP" RIVETS WORK



"POP" Rivets are inserted and set from the same side of the work. The retracting jaws in the setting tool pull the mandrel head into the rivet on the reverse side until the mandrel breaks under tension. This high clinch action pulls parts together exerting up to 600 lbs. squeeze and produces a tight, positive, vibration-proof fastening over a wide range of stock variations.

ONLY $19.95 prepaid

Let This Kit Introduce You To "POP" Rivets

Discover this new way to simplify design, improve quality and speed production. Introductory kit contains approximately 240 "POP" Rivets in various lengths and materials together with a hand setting tool. Complete with instructions and application hints. "POP" Rivets can save as much as 50% on installed costs!

A FEW OF THE ADVANTAGES OF "POP" RIVETS

- Lower installed costs by as much as 50%.
- Stops vibration worries. Cannot back out or shake loose.
- Allows more compact designs — less back-up space required. Only 3/16" needed on "blind" side.
- Reduces weight and material costs by allowing use of thinner sheets. Hold tight even in .020 aluminum. No stripping or distortion.
- Resists corrosion by eliminating surface marring and chipping.
- Allows wider choice of materials such as fastening plastic to metal, wood to metal, etc. "POP" Rivets hold by compression. Controlled radial expansion prevents fracture of brittle materials.
- Allows use of non-critical hole diameters which assures strength to satisfy design considerations combined with speed of assembly.
- Complete selection of hand and power tools available for production rates to 1200 rivets per hour.

USS-60

"POP" RIVET DIVISION
UNITED SHOE MACHINERY CORPORATION
31310 River Road, Shelton, Conn.

SEE SWEET'S DESIGN FILE FOR COMPLETE CATALOG OR WRITE FOR YOUR PERSONAL COPY

UNITED "POP" RIVETS

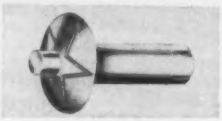
Circle F-52 on Page 97

Design Features: Provides positive sealing between rivet and bore without the addition of foreign sealing agents. Headless type rivets are for use with automatic machines. Two other available types, the washer rivet and the replacement rivet, have preformed heads and are driven with conventional hand tools.

Materials: Shank is 2117-T4 aluminum alloy, sleeve is 1100 aluminum alloy.

Sizes: 5/32, 3/16, and ¼-in. diameter.

Source: Pastushin Industries Inc., Los Angeles, Calif.



Pin-Grip

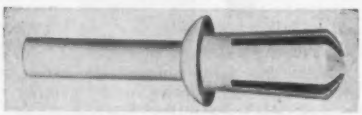
Form: Two-piece, tubular, blind rivet consisting of preassembled slotted sleeve and knurled drive pin. When pin is driven flush with head, slotted sleeve expands on blind side to form blind head. Simultaneously, the knurled pin locks itself in position.

Design Features: Rivet is easily driven from one side with hammer. Knurled pin provides positive lock of sleeve and resists vibration. Suitable for blind or limited-access applications.

Materials: Sleeve is aluminum, pin is stainless steel.

Sizes: ⅛ to ¼-in. nominal diameter. Various grip lengths. Head styles include universal, countersunk, full brazier, round and flat splash, and punel.

Source: Star Expansion Industries Corp., Mountainville, N. Y.



Plasti-Rivet

Form: One-piece, self-expanding, plastic blind rivet. Projecting pin on driving side is released from its plastic collar and driven into rivet shank by blow. Prongs on blind end of shank are expanded by pin to provide positive locking action.

Design Features: Expansion gripping action resists loosening effects of vibration. Driven rivet is nonconductive, stable over wide temperature range, and corrosion resistant. Each rivet provides range of grip lengths. Permits rapid assembly in blind or open locations. Uses include metal-to-plastic joining, clock mounting, hinge fastening, and name plate attachment.

Materials: Thermoplastic compositions (nylon, acetate, butyrate, polystyrene, or polyethylene).

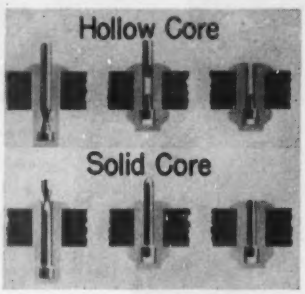
Sizes: ⅛ to ⅜-in. nominal diameters. Grip lengths from 1/64 to ⅝-in. Head styles include round, countersunk, and truss.

Source: Fastex Div. of Illinois Tool Works, Des Plaines, Ill.

Pop Closed-End Rivet

Form: Two-piece tubular blind rivet consisting of preassembled closed-end hollow rivet and headed mandrel (also known as Imex rivets). Retracting jaws in setting tool pull mandrel into rivet to form blind head. When rivet is driven, tail of mandrel breaks off. There are two rivet types: In the hollow core type, mandrel breaks near head eliminating need for secondary trimming operation; in solid core type, mandrel protrudes after breaking and is trimmed flush with surface of rivet head.

Design Features: Provides a sealed blind rivet which is watertight and airtight under pressures up to 500 psi. Radial expansion of rivet during setting provides hole-filling characteristics. Used primarily for high-speed metal fabrication in open or blind locations where a sealed blind rivet is required. Hollow-core type is used where weight is a factor and high shear strength is not required. Solid-core type has added strength provided by solid mandrel section.

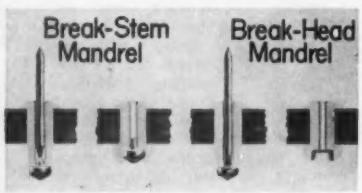


Materials: Rivet is aluminum, mandrel is steel.

Sizes: ⅛, 5/32, and 3/16 in. nominal diameters. Several grip lengths. Head styles are domed or countersunk.

Source: Pop Rivet Div., United Shoe Machinery Corp., Shelton, Conn.

(See Ad, Page 181)



Pop Open-End Rivet

Form: Two-piece tubular blind rivet consisting of preassembled hollow rivet and headed mandrel. Retracting jaws in setting tool pull mandrel head into rivet to form blind head. When rivet is driven, mandrel breaks under tension and comes free.

Design Features: High-production fastener with wide grip range. Provides controlled radial expansion to prevent fracture of brittle panel material. Low head profile requires minimum clearance space. Strength of hollow Monel rivet is equivalent to conventional solid aluminum rivet. Used primarily for high-speed metal fabrication in open or blind locations.

Materials: Aluminum, Monel, copper, and steel.

Sizes: 3/32 to 3/16 in. nominal diameters. Several grip lengths. Head styles include domed and countersunk.

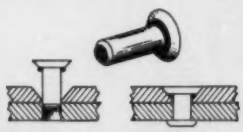
Source: Pop Rivet Div., United Shoe Machinery Corp., Shelton, Conn.

(See Ad, Page 184)

Riv-O-Seal

Form: Preassembled, flush-head solid rivet and O-ring. When rivet is set by conventional methods, round cross section of O-ring changes to triangular shape to fill controlled void under rivet head.

Design Features: Rivet design is based on principle of controlled confinement of



rubber and provides positive seal which is effective under high and low pressure. Simplifies flush rivet sealing problems and eliminates need for sealing "pastes." Particularly suited to applications where sealed flush rivet is required.

Materials: Rivet is aluminum; O-ring is silicone or black nitrile rubber.

Sizes: 3/32 to 5/16-in. nominal diameters. Grip lengths from 0.040 to 0.125 in. Head style is countersunk.

Source: Parker Seal Co., Culver City, Calif.

Robin Riv-Jt

Form: One-piece, all-metal, clinch-type fastener for sheet metal parts. Fastener body is made of metal strip shaped to form two small tabs, side by side, and two larger wing tabs. Small tabs are inserted in suitable round or rectangular hole in sheet material and larger wing tabs are clinched together by pliers or air operated gun. This action spreads smaller tabs, drawing parts together against head formed by clinched tabs.

Design Features: Provides low-cost, rapidly-assembled, rivet-type blind fastener for sheet-metal parts. Forms tight, vibration-resistant joint. Can tolerate wide degree of misalignment in assembly. Eliminates need for torquing tools.

Materials: Cold-rolled steel.

Sizes: 5/16 to 13/32 in. nominal hole sizes. Total panel thicknesses from 0.045 to 0.158 in. Body styles include several small and large tab designs.

Source: Robin Products Co., Warren, Mich.

Seelrivit

Form: Preassembled standard solid rivet and O-ring washer. As rivet is set by conventional methods, O-ring flows to produce liquid and gas-tight seal under head.

Design Features: Reservoir under head confines O-ring and permits full metal-to-metal contact. Eliminates separate handling of rivet and sealant. Can be used to seal out air, gases, and fluids at pressures up to 2500 psi. Temperature

3-Point Support Helps You Design for Simpler, Lower-Cost Assembly

RIVETS

TRS offers you an unsurpassed choice of tubular rivets, quickly available to handle almost any fastening problem. Also, the Perma-Nut, a versatile combination of rivet and nut. You can't beat rivets for low in-place cost . . . or TRS rivets for uniform, trouble-free performance.

RIVETING MACHINES

TRS has the machines, no matter what the type or capacity, to help you obtain the full money-saving advantages of automatic riveting as an assembly method. With TRS riveters, impossible-to-rivet jobs often become practicable . . . standard jobs always become more efficient.

PAR PROCESS

A TRS man puts the PAR PROCESS to work for you through a planned check of your assembly operations. Aimed at improving efficiency by eliminating, simplifying, speeding up steps, this unique TRS approach makes riveting practically a new method of assembly.

USE TRS SUPPORT early in your planning. Invite a TRS Engineer to demonstrate the unequalled combination of fasteners, machines and know-how that has uncovered important economies for hundreds of assemblers.

TRS®

TUBULAR RIVET & STUD COMPANY

QUINCY 70, MASSACHUSETTS • TRS SALES OFFICES: Atlanta • Buffalo • Charlotte • Chicago Cleveland • Dallas • Detroit • Hartford • Indianapolis • Los Angeles • New York Philadelphia • Pittsfield • Quincy • St. Louis • Seattle. WAREHOUSE IN CHICAGO

See "Yellow Pages" for phone numbers.

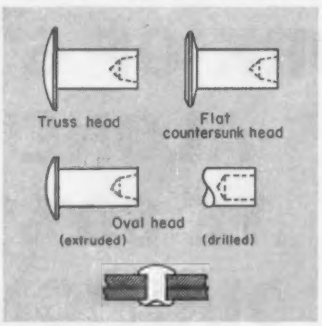
If it's a Tubular Rivet TRS makes it . . . and Better

range is −160 to 500 F.

Materials: Rivet is aluminum alloy; O-ring is silicone rubber.

Sizes: ⅛ to ⅜-in. shank diameters. Shank lengths from 3/16 to 4 in. Head style is aircraft universal.

Source: A. P. M. Corp., Yonkers, N. Y.



Semitubular Rivet

Form: One-piece, solid metal rivet with shallow drilled or extruded hole in end of shank. Hole depth does not usually exceed shank diameter. Rivet is inserted in prepared hole and clinched with anvil in rivet-setting machine.

Design Features: Provides a low-cost, high-production fastener for light assemblies. Hole in end of shank facilitates clinching. Driven rivet has shear and compression strength equal to comparable solid rivet.

Materials: Steel, aluminum, brass, stainless steel, or copper.

Sizes: 0.058 to 5/16-in. shank diameters. Shank lengths from 3/16-in. up. Head styles include oval, truss, and countersunk.

Source: Produced by several manufacturers. Information and illustration, courtesy The Tubular and Split Rivet Council, New York, N. Y.

(See Ads, Pages 175, 177, 179, 183, 185)

Solid Rivets

Form: Standard one-piece, solid metal rivets. Rivet shank is inserted in prepared hole and head is hot or cold formed on shank end with a set or forming tool. Setting can be accomplished by hand or by hydraulic or pneumatic-operated driving equipment.

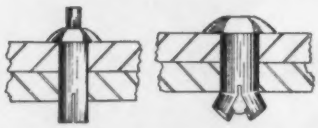
Design Features: Provides a simple, reliable, low-cost permanent fastener. Driven rivet has a neat appearance. Produces sound, uniform joints when properly driven.

Materials: Steel, brass, aluminum, corrosion-resistant steel, or other materials.

Sizes: No. 14 to 7/16-in. nominal diameters for small rivets; ½ to 1¾ in. for large rivets. Head styles include flat, countersunk, button, pan, truss, tinners, coopers, and belt for small rivets; button, high button (acorn), flat-top countersunk, round-top countersunk, cone, and pan for large rivets.

Source: *American Standard Small Solid Rivets*—ASA B18.1-1955; *American Standard Large Solid Rivets*—ASA B18.4-1950. Photo, courtesy Anti-Corrosive Metal Products Co. Inc., Castleton-on-Hudson, N. Y.

(See Ad, Page 179)



Southco Drive Rivet

Form: Two-piece, tubular, blind rivet consisting of preassembled slotted, cored rivet and steel grooved pin. Rivet is upset by driving pin into shank to expand prongs on blind side.

Design Features: Rivet shear strength is comparable to solid rivet. Formed blind head is reinforced by pin. Rivet can readily be installed with hammer; no finishing off is required. Pull-up action of expanding prongs draws parts tightly together. Metal flow produced by driving operation aids locking action. Particularly suited to blind and access locations in structures able to support driving forces.

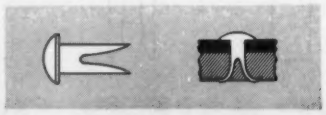
Materials: Rivet body is steel or aluminum; pin is steel or stainless steel.

Sizes: ⅛ to ¼-in. nominal diameters. Grip lengths from 1/32 to ⅝-in. Head styles include modified brazier and countersunk.

Source: Southco Div., South Chester Corp., Lester, Pa.

Split (Bifurcated) Rivet

Form: One-piece metal rivet with a two-prong shank formed by sawing or punching solid rivet. Rivet is driven through material to be fastened and clinched against a solid form that bends back prongs and presses them into work.



Design Features: Provides low-cost, high-production permanent fastener for joining light-gage metals, or fibre, wood and plastic materials. Since rivet is self-piercing, need for separate hole-forming operation is eliminated. Can be capped to prevent clinch from tearing material and to improve appearance and strength.

Materials: Steel, aluminum or brass.

Sizes: 0.080 to 3/16-in. nominal shank diameters. Shank lengths from 3/16-in. up. Head styles include oval, truss and countersunk.

Source: Produced by several manufacturers. Information and illustration, courtesy The Tubular and Split Rivet Council, New York, N. Y.

(See Ads, Pages 175, 177, 179, 183, 185)

Trimount Stud Fasteners

Form: All-metal, rivet-type fasteners with capped or uncapped flange head and split-hollow shank or barbed shank. Fastener is pushed into prepared hole, or mating stamped locking member mounted over or in prepared hole, in panel sections.

Design Features: Used for rapid assembly of sheet metal, plastic, or composite panels. Can be used to attach either flexible or rigid panel sections. Can be pushed into drilled, stamped, or molded holes by finger pressure alone. Decorative caps can be used to enhance appearance of flange head.

Materials: Brass or steel.

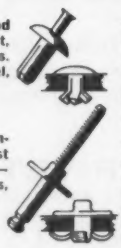
Sizes: 3/32 to 0.320 in. nominal hole size. Grip lengths from 0.075 to 1¾ in. Fastener designs include removable and permanent types. Body styles include shoulder, barrel, and locking types.

Source: Carr Fastener Co., Div. of United-Carr Fastener Corp., Cambridge, Mass.

Olympic Rivets *for all fastening applications*

BLIND RIVETS, self-plugging and pull-through type, for aircraft, missile and industrial applications. Made in aluminum, steel, monel, stainless and hi-temp metals.

"OSCAR" RIVETS, the economy industrial blind fasteners, for fast assembly of metal products — trailers, mobile homes, boats, metal furniture, appliances, etc.



"HIT" and "DRIVE-TITE" RIVETS, blind type drive pin rivets which are installed from one side by a hammer blow. Widely used in metal building construction and in attaching metal to frames and structures.

"HI CLINCH" RIVETS, "pull" blind rivets designed especially for metal building construction to fasten thin sheets where clinch is required. Useful for fastening roofing and siding sheets and attaching sheets to beams and girders.

SOLID RIVETS — All Sizes — All Metals — All head styles for aircraft, missiles and industrial uses. Made in aluminum, monel, steel, stainless steel, brass and hi-temp metals.

SPECIAL RIVETS and Cold Headed Fasteners are designed and adapted by Olympic to high speed cold heading for the resulting economy and increased strength.

Write for catalog and information.

Olympic Screw & Rivet Corporation

11441 SOUTH DOLAN STREET DOWNEY, CALIFORNIA

Phone: SPruce 3-2060
Teletype: Downey 6072
Cable Address: Screws, Downey

Photo courtesy Ark-Les-Switch Corp., Watertown, Mass.

FREE...75 YEARS OF FASTENING EXPERIENCE!

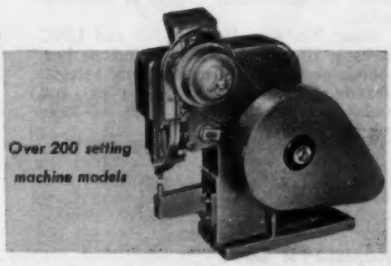
All Thomson rivet customers are serviced by men backed by a company 75 years young!

You get more per fastening dollar when Thomson becomes your fastening partner. You get on-the-spot service from a man who can tap a pool of experience no other source of rivets and rivet-setting machines can match.

Since 1885, J. L. Thomson Mfg. Co. has kept pace with fastening progress . . . continuously matching new rivets and automatic setting machines to product-improvement and cost-reduction demands. The result: more than 8,000 rivet specifications and more than 200 machine models . . . ready answers to your fastening problems.

Your local Thomson Fastening Man, listed in the Yellow Pages, can help you select the right rivet-and-machine combination. Thomson's new handbook is another valuable source of up-to-date information. For your copy of "Cost-Cutting Facts About Fastening With Rivets", address your letter to Dept. 23.

Over 8000 rivet specifications



Over 200 setting machine models

JUDSON L. THOMSON MFG. CO.
WALTHAM 54, MASS.

Thomson (Canada) Rivet Co. Ltd., Gananoque, Ontario

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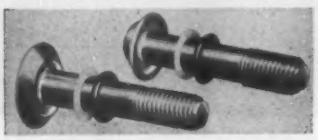
PRODUCT DIRECTORY

CHAPTER 27

Screws, Bolts, and Studs

OF basic importance in design, screws, bolts, and studs define a large family of externally threaded fasteners that offer practical advantages in ease of assembly and disassembly. Making a distinction between each of the types is often difficult. Trade designations are frequently representative of old original usage and have been maintained for convenience. Many of the screw, bolt, and stud types have been standardized. An even greater number have not. Types presented here are generally representative of both groups but do not include many special-purpose designs available from individual manufacturers.



Absco Self-Sealing Screw

Form: Single-unit, self-sealing screw consisting of screw with thin Teflon washer and O-ring mounted in groove on bottom side of screw head. When screw is tightened, O-ring flows to provide seal and Teflon washer reduces friction between screw head and O-ring.

Design Features: Reusable. Design facilitates rapid assembly and does not require lubrication for installation. Eliminates separate handling of screw and sealant, as well as secondary operations. Can be used with oversize holes.

Materials: Screw is carbon or alloy steel, passivated corrosion-resistant steel, brass, or aluminum; O-ring is synthetic rubber.

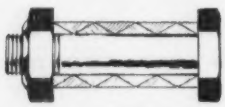
Sizes: No. 4 to ½-in.; UNF and UNC threads; Class 3. Head styles include hex, round, and countersunk. Driving recesses include slotted, Phillips, Torq-Set, and socket. Screw types also include self-locking and captive designs.

Source: Aero Bolt & Screw Co. Inc., Inglewood, Calif.

(See Ad, Page 220)

Adjusto-Fit Bolts

Form: One-piece, all-metal bolt assembly with an adjustable-diameter body. Assembly consists of hex-head bolt, hex nut, and adjustable-diameter bushing. When nut is tightened, adjustable bushing OD expands to grip hole wall, and ID contracts to grip the shank of the bolt. Bolt draws up the joint at the same time the bushings are expanding.



Design Features: Provides an interference-fit, body-bound bolt without need for accurate prepared hole. Bolt develops high pull-up force. Will tolerate considerable misalignment; holes can be rough drilled and as much as 0.060 in. oversize.

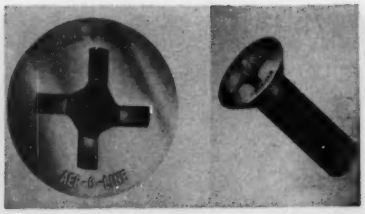
Materials: Steel, corrosion-resistant steel, stainless steel, aluminum, and high-strength steel.

Sizes: 5/16 in. diameter up.

Source: Adjustable Bushing Co., North Hollywood, Calif.

Aer-O-Torq Bolts

Form: High-strength, flat-head aircraft bolt with internal driving recess of offset cruciform design. Bolt is tightened with conventional, manual, or power-operated driving tools fitted with offset bits.

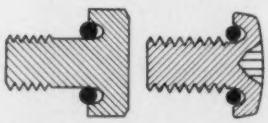


Design Features: Offset recess design prevents ream-out, even under extreme tightening torque. Provides even distribution of driving torque. Particularly suited for use where a high preload is required and failure during assembly and removal must be avoided.

Materials: Heat-treated alloy steel.

Sizes: No. 2-56 to 1-in. nominal diameters. Coarse and fine threads. Variable lengths. Recess design can be adapted to machine screws, cap screws, bolts, and tapping screws for industrial and commercial applications where high driving torque is required.

Source: Aer-O-Line Mfg. & Supply Co., Burbank, Calif.



APM Sealing Fasteners

Form: Preassembled bolt or screw and O-ring washer. When bolt or screw is tightened, O-ring flows to produce liquid and gas-tight seal under head.

Design Features: Reusable. Provides a rapidly assembled self-sealing fastener. Eliminates separate handling of fastener and sealant. Sealing action is effective against external and internal liquid pressures up to 500 psi for screw, 2500 psi for bolt. Temperature application range is −160 to 500 F. Can be used to seal out dust and combustible vapors.

Material: Screw is stainless steel; bolt is carbon steel; O-ring is silicone rubber.

Sizes: No. 4 to ¼-in. screws; No. 10 to ½ in. bolts; Coarse and Fine threads.

Source: Automatic and Precision Mfg. Corp., Yonkers, N. Y.

(See Ad, Page 204)

Barpad Fasteners

Form: Finished round, hex, or flat headed screw or bolt with compressible type washer attached under the head as an integral part. Tightening fastener compresses washer material onto fastened member and into the clearance hole between fastener and fastened member.

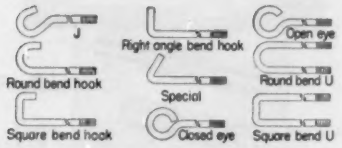
Design Features: Suitable for light to medium torque requirements. Washer provides effective sealing of air, liquids, or gases at low or high pressures. Applica-

tion temperature range is −65 to 1100 F. Can be used to provide insulated or cushioned fastener. Eliminates separate handling of fastener and washer.

Materials: All standard engineering materials, and natural or synthetic sealing, insulating, and cushioning materials.

Sizes: All standard screw and bolt diameters.

Source: L. J. Barwood Mfg. Co. Inc., Everett, Mass.



Bent Bolts

Form: Threaded rods with special bent shank shapes.

Design Features: Used in applications where a formed shank shape, rather than a standard head, is desired for assembly purposes.

Materials: Steel, brass, bronze, aluminum, or stainless steel.

Sizes: All standard diameters; Coarse and Fine threads. Body styles include J, hook, eye, and U.

Source: Industrial Fastener Institute Standard.

Blind Bolt

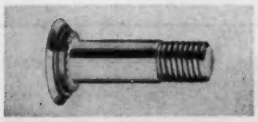
Form: Three-piece, all metal bolt assembly consisting of a countersunk or protruding headed sleeve, a threaded expander nut, and a core bolt. Sleeve and expander are inserted into prepared hole. Expander is pulled up by installation tool mandrel into sleeve end, expanding blind end of sleeve to lock the two pieces together. Core bolt is then screwed into assembled sleeve and expander.

Design Features: Provides high-strength fastener which can be installed from one side of work for repair or assembly of aircraft, missiles, and related structures. Shear strength comparable to 95,000 psi NAS bolt. Tensile values equal to or exceed AN bolt. One grip length size accommodates 0.090-in. work thickness. Can be used at elevated temperatures to 800 F. Requires only standard hole preparation, no reaming. Resists vibration and fatigue.

Materials: Stainless steel or A286 alloy steel.

Sizes: 5/32 through ½-in. nominal diameters. Sleeve head styles include countersunk and protruding.

Source: Hi-Shear Rivet Tool Co., Torrance, Calif.



Bolt-O-Seal

Form: Flush-head bolt with special rubber seal built into bottom side of head. Design of seal is based on principle of controlled confinement of rubber and provides a positive sealing action when bolt is tightened.

Design Features: Reusable. Provides a self-contained sealing bolt that can be used with most liquids and gases. No cold flow is developed in rubber, which keeps its elastic memory. Stress and strength factors are maintained by metal-to-metal contact of faying surfaces. Application temperature range is 100 to 375 F.

Materials: Bolt is high-strength steel; seal is white silicone or black nitrile rubber.

Sizes: No. 8-32 to ⅜-24. Head style is countersunk with Phillips recess.

Source: Voi-Shan Mfg. Co., Div. of Voi-Shan Industries Inc., Culver City, Calif.

Calinoy Captive Screw

Form: Two-piece, all-metal, captive-screw assembly consisting of screw spring-mounted in a housing, and a retainer nut. Countersunk hole is prepared in sheet that screw is to be attached to, then retainer nut is placed on one side of sheet and the screw is threaded through the nut. Screw is then used to attach sheet to threaded hole or anchor nut.

Design Features: Designed specifically for fastening of electronic modules or other removable components. When screw is loosened from anchor nut or tapped hole, it is snapped back inside retainer nut to provide flush surface.

Materials. Housing and retainer nut are anodized aluminum, screw is steel.

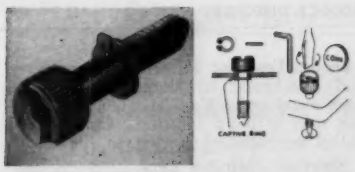
Sizes: No. 10-32NF screw thread. Panel thicknesses from 0.062 through 0.437 in.

Source: Calinoy Div. of Illinois Tool Works, Hawthorne, Calif.

Cap-Captive Screw

Form: Cap screw with concave surface on top of head and combination hexagon socket and slotted driving recess. Shank of screw is smaller than rolled threads, permitting the screw to be made captive in panel by installation of retaining ring over shank.

Design Features: Eliminates loose parts. Head design simplifies screw assembly;



can be tightened or loosened with several tools, including a coin. Adaptable to high-speed production assembly.

Material: Steel.

Sizes: No. 6-32 to ¼-20. Various grip lengths. Point styles include chamfered, bullet-nose, and pilot-guide.

Source: Alden Products Co., Brockton, Mass.

Cap Screws

Form: High-quality headed and threaded screw fastener. End of threaded shank has a chamfer point.

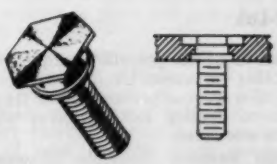
Design Features: Provides a general-purpose screw fastener for use in tapped holes. Used where a screw of high strength, fine tolerances, or quality finish is required.

Materials: Heat-treated or alloy steel, brass, bronze, corrosion-resistant steel, aluminum, and other materials.

Sizes: No. 0 to 1½ in. nominal diameters; Coarse, Fine, and 8-thread series; Class 2A and 3A. Lengths from ⅜ to 6 in. Head styles include hex, flat, round, fillister, and socket. Driving recesses include slotted, and hex and fluted sockets.

Source: *American Standard Hexagon Head Cap Screws, Slotted Head Cap Screws, Square Head Set Screws, and Slotted Headless Set Screws*—ASA B18.6.2-1956; *American Standard Socket Head Cap Screws and Socket Set Screws*—ASA B18.3-1954. Photo, Courtesy Standard Screw Co., Bellwood, Ill.

(See Ads, Pages 199, 203, 205, 206, 208 210, 215, 220, 222)



Captive Stud

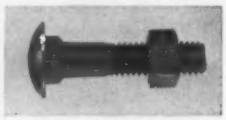
Form: Standard threaded stud with insert-type head. Head has hex flange separated from reduced-diameter round flange by annular grooves. Head is pressed into prepared hole, round flange first, and hex flange is seated flush with part surface. Cold flow of material into grooved section and around hex flange locks stud securely in place.

Design Features: Provides a permanent stud attachment in aluminum or brass sheet-metal parts. Can be assembled from one side in blind locations. Can be installed on standard presses.

Material: Stainless steel.

Sizes: No. 4, No. 6, and No. 8 NC-2A and No. 10 NF-2A threads. Lengths from 3/16 to 1 in. Sheet material thicknesses from 1/16 to 1/4 in.

Source: National Radio Co. Inc., Melrose, Mass.



Carriage Bolts

Form: Standard round-head bolts with square or ribbed neck shape to prevent rotation when nut is tightened. Square-neck type is mounted in a square punched hole; ribbed-neck type is driven into hole with an interference fit or staked in place.

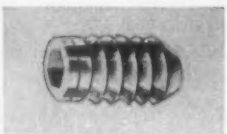
Design Features: Used in applications where it is impractical to hold the bolt head while tightening the nut. Short square-neck type can be used in steel assemblies to fasten sheet-metal parts; it usually requires a mounting hole only in the first metal sheet under the head. Square-neck design is also useful for fastening castings and forgings because of the tolerance permitted by its neck shape. Ribbed-neck type can be employed with plastic or other similar materials.

Materials: Steel.

Sizes: No. 10 to ¾-in. nominal diameters; Coarse threads; Class 2A. Lengths from ½-in. up. Head styles include several other neck shapes.

Source: *American Standard Round Head Bolts*—ASA B18.5-1952. Photo, courtesy Standard Screw Co., Bellwood, Ill.

(See Ads, Pages 210, 214)



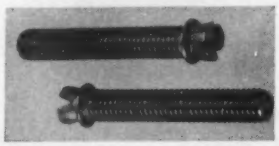
Crest-Lok

Form: Headless, prevailing-torque type, self-locking set screw. Unthreaded section at top of screw compresses crest of tapped threads to develop locking action when screw is assembled.

Design Features: Reusable. Eliminates need for precise tapping. Particularly suited for use in plastic and soft-steel parts. Locking action may be increased or decreased by changing tap drill diameter.

Sizes: No. 4 to ¾ in. nominal diameters. Various lengths. Body styles include headless slotted, and fluted and hex socket. Point styles include cup, flat, cone, oval, half and full dog, and hangar.

Source: Set Screw & Mfg. Co., Bartlett, Ill.



CSM Screw Insert

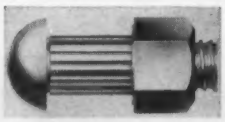
Form: Collar screw with head split into three equally spaced segments. Screw head is molded into plastic parts.

Design Features: Provides a strong, permanent stud attachment for plastic parts. Slotted head design develops high holding powers. Base of head is molded flush with material surface and enhances appearance.

Materials: Stainless steel.

Sizes: No. 6 to ⅜ in.

Source: CSM Screw Products Co., Chicago, Ill.



Dardelet Rivet Bolt

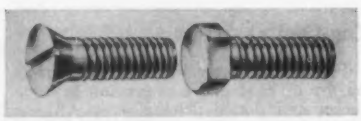
Form: All-metal, free-spinning locking bolt assembly. Bolt consists of standard rivet head and shank which is axially ribbed at upper end and has special locking thread to receive mating nut. Bolt is driven into prepared hole, causing ribs to deform and grip hole wall to give body-bound fit. Nut is then applied and tightened against seating surface. Axial tightening force drives crest of nut thread along tapered root surface of bolt thread, producing a positive locking action when the point of maximum root diameter is reached.

Design Features: Nut turns down freely until sealed, then is wrench tightened. Provides high shear and bearing strength, equal to power-driven rivets or turned bolts in reamed holes. Resists loosening under extreme shock and vibration conditions. Used in steel structures where a high-strength, easily assembled, seated locking bolt is required.

Material: Steel.

Sizes: ⅜ to 1 in. nominal diameters. Lengths from ⅜ to 4 1/16 inches. Head style is ASA button (large rivets).

Source: Bethlehem Steel Co., Bethlehem, Pa.



Delron High-Temperature Fasteners

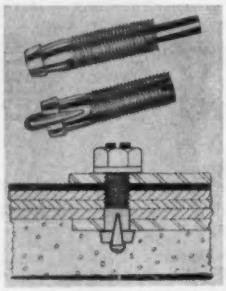
Form: Standard headed bolt or screw with special truncated thread.

Design Features: Thread design minimizes galling and seizing at elevated temperatures. Suitable for use at temperatures up to 1600 F. Can be used with conventional nut or in a tapped hole.

Material: 19-9DL stainless steel.

Sizes: No. 10-32 to ⅜-24 nominal sizes. Lengths from ½ to 3 in. Head styles include round and flat.

Source: The Delron Co. Inc., South Gate, Calif.



Drivebolt

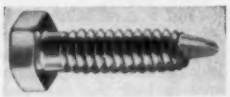
Form: Single-unit, blind-bolt assembly consisting of hollow bolt and drive pin. Bolt is inserted in drilled hole with nut and lock washer loosely attached and pin is driven into shank to form blind head. Nut is then wrenched tight. Nut end of bolt is slotted and is held by screwdriver to prevent turning while nut is wrenched.

Design Features: Provides a high-strength bolt attachment in blind locations where standard bolts cannot be used. Has high shear and tensile strength. Does not require special assembly tools.

Material: Steel.

Sizes: ⅜-24 screw thread. Grip range from ⅜ to ⅞ in.

Source: Southco Div., South Chester Corp., Lester, Pa.



Eaton-Reliance Self-Drill Screw

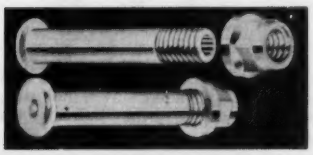
Form: All-metal tapping screw designed to be used without prepared hole. Screw has hardened, thread-forming type tapping threads and modified half-gimlet point. Point forms its own starting hole as screw is driven into place like conventional tapping screw.

Design Features: Drills and taps its own hole in sheet metal, plastics, and wood. Can be adapted to high-speed assembly methods. Eliminates problems of positioning and hole matching. Can be used with both manual and power-driven power heads. Can be used in plastic and sheet metals with thicknesses up to ½ in. screw diameter.

Material: Steel.

Sizes: No. 6 to ⅜ in. nominal bolt sizes. Lengths from ¾ to 1½ in. Head style is recessed hex.

Source: Reliance Div., Eaton Mfg. Co., Massillon, Ohio.



Fastbolt

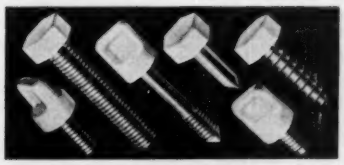
Form: All-metal bolt assembly consisting of a bolt with diaphragm head and recessed socket in thread end, and a prevailing-torque locknut. Nut is integral washer unit with hex wrenching surfaces. Washer surface has 1 deg internal angle which provides positive tension lock when seated and tightened. The threads in tail section of nut are swaged uniformly to a reduced size which provides secondary locking action against threaded section.

Design Features: Recessed socket permits bolt to be held from driving side for semiblind application. The internal angle in washer surface distributes torque load evenly and provides positive locking action.

Materials: Aluminum, high-temperature alloy steel, and titanium.

Sizes: 3/16 to 1/2-in. nominal diameter. Head styles include protruding diaphragm and countersunk flush head.

Source: Voi-Shan Mfg. Co. Div. of Voi-Shan Ind. Inc., Culver City, Calif.



GRC Self-Insulating Fasteners

Form: Metal threaded or unthreaded shanks with molded-on plastic heads.

Design Features: Plastic heads prevent corrosion and moisture absorption by sealing at critical points. They withstand impact, have good electrical and thermal insulating properties, and prevent galling of contact surfaces.

Materials: Heads are plastic; shanks are ferrous and nonferrous metals.

Sizes: Standard thread and rivet diameters. Fastener types include screws, bolts, and rivets.

Source: Gries Reproducer Corp., New Rochelle, N. Y.

(See Ad, Page 201)

High Strength Bearing Bolt

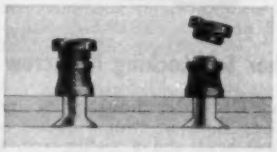
Form: All-metal bolt assembly. Bolt consists of standard button head and shank which is knurled, and has standard threads to receive mating hex nut and hardened washer. Bolt is driven into prepared hole, causing knurled teeth to deform in a body-bound fit that locks bolt securely in place. Nut is then applied and tightened against seating surface to predetermined torque value. High preload in bolt supplies nut-locking force.

Design Features: Develops high-force locking grip. Provides higher shear and bearing strength than equivalent power-driven rivets. Nut and washer are reusable. Spiraled-pattern tooth design and shaped teeth allow bolt to be driven with hand hammer. Facilitates driving but resists removal. Used in rugged, heavy-duty assemblies or structures where stress, shock, or vibration conditions are unusually severe.

Material: High-carbon steel.

Sizes: ⅝, ¾, ⅞, and 1 in. nominal diameters. Grip lengths from 7/16 to 4 1/16 in.

Source: The Lamson and Sessions Co., Cleveland, Ohio.



Hi-Lok

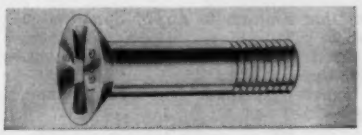
Form: Two-piece, all metal, high-strength bolt type fastener, consisting of externally threaded pin and internally threaded, self-locking collar. Threaded end of pin contains hex-shaped recess which is engaged by hex wrench tip of driving tool to prevent rotation of pin while collar is being installed. Base of collar has internal counterbore which accommodates variations in material thickness. Other end of collar carries a wrenching device which shears off when torqued to a predetermined preload by the driving tool.

Design Features: Combines features of rivet and bolt. Can accommodate up to 1/16 in. variation in material thickness. Provides controlled preload consistent within 10 per cent. Has minimum size and weight. Permits installation from one side of work. Can be adapted to high-speed assembly methods.

Materials: Titanium, alloy steel, stainless steel, and aluminum.

Sizes: 3/16 to ⅜-in. pin diameters. Head styles include protruding and countersunk flush.

Source: Hi-Shear Rivet Tool Co., Torrance, Calif.



Hi-Torque Bolt

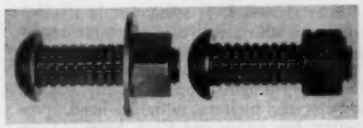
Form: High-strength machine bolt with undercut, slotted driving recess that is wider at the periphery of the head than at the center. Bolt is tightened with a standard or special driver using a relieved, disc-shaped bit.

Design Features: Can withstand high tightening torques. End thrust is not required to keep driving tool in position during tightening. Used primarily where torquing to a high preload is required.

Materials: Alloy steel; 17-4 PH, 431 and AM 350 stainless steel; A286 alloy; AMS 5668 Inconel X; 6 AL-4V titanium.

Sizes: Thread sizes from 4-40 NC-3A. Various lengths. Head styles include 100 deg countersunk, protruding, and pan head.

Source: Hi-Shear Rivet Tool Co., Torrance, Calif., and Voi-Shan Mfg. Co., Div. of Voi-Shan Industries Inc., Culver City, Calif. Photo, courtesy Hi-Shear Rivet Tool Co.



Interrupted Rib Bolt

Form: All-metal, high-tensile, structural bearing bolt assembly. Bolt consists of a flattened round head and shank which has axial interrupted ribs at upper end and a standard thread. Mating prevailing-torque hex locknut is used with bolt where high clamping force is not required or cannot be obtained because of torquing difficulties. Heavy semifinished hex nut and hardened washer are used where high clamping force must be developed. Bolt is hammered into prepared hole and drawn up tight by wrenching nut. Interrupted ribs cut through the joint members, creating a body-bound fit that locks bolt securely in place and puts it in bearing at all times.

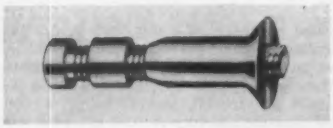
Design Features: Interrupted ribs fill hole to produce a body-bound fit that minimizes possibility of joint slippage. Underside of bolt head is tapered so that greatest bearing is near outer circumference of head, reducing stress concentration at holes. Flattened head of bolt and design of ribs, which are relatively hard and tapered on the nut side, facilitate driving. Ribs burnish grooves in holes of joint members but do not peel off when driven, preventing packing of material under bolt head. Bolt is designed with proper length of rib for thickness of joint members to prevent the riding of any steel on the bolt threads and to put the joint members in full bearing.

Materials: Bolts, nuts, and washer are steel with physical and chemical proper-

ties that conform to ASTM Specification A-325.

Sizes: 5/8 to 1 in. nominal diameters, NC threads, Class 2A.

Source: Automatic Nut Co., Lebanon, Pa.



Jo-Bolt

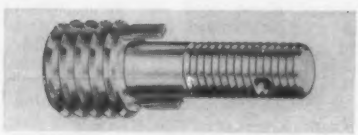
Form: Single unit, blind fastener consisting of preassembled bolt, nut, and sleeve. Bolt is inserted in prepared hole through members to be joined and power or hand driver is applied to wrench bolt while nut is held. Sleeve is compressed between bolt head and conical end of nut, and drawn over taper to form blind head that grips mating surface of members being joined. Positive sheet clamp-up is simultaneously effected. Slabbed portion of bolt shank is snapped off when bolt is fully driven.

Design Features: Provides high shear and tensile strength. Resists vibration. Light weight. Adaptable to high-speed production methods.

Materials: Bolt is steel, nut is steel or aluminum alloy, sleeve is corrosion-resistant steel.

Sizes: No. 8 to 3/8 in. nominal diameter. Grip lengths from 0.031 to 1.031 in. Body styles include millable head, protruding hex head, and flush head.

Source: National Screw & Mfg. Co., Cleveland, Ohio.



Keensert Stud

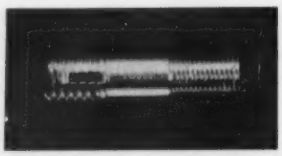
Form: Single-unit, self-locking, tap-end type stud assembly consisting of nut-end threaded section and enlarged "tap" end with stepped keys mounted in dovetail grooves on opposite sides. Stud is screwed into standard tapped hole. Keys are then pressed into tapped threads with a small punch and hammer, or simple installation tool to lock stud in place.

Design Features: Provides a secure, easily installed, threaded stud attachment in aluminum, magnesium, plastics, and other relatively soft materials. Can be installed by hand in holes tapped with standard tools. Stepped keys provide positive resistance to stud rotation. Elminates the need for special thread fits to obtain secure locking action.

Materials: Corrosion-resistant steel and chrome-moly steel.

Sizes: No. 2-56 to 1 in. nut-end threads.

Source: Newton Insert Co., Los Angeles, Calif.



Kelox Stud

Form: Two-piece, self-locking, tap-end type stud assembly consisting of stud and locking ring which has two keys extending from bottom surface. After stud is installed in tapped hole, ring is pressed into place at top of hole with keys extending down into mating axial grooves in stud thread. Keys cut through sufficient threads in the tapped hole to provide a positive lock.

Design Features: Provides a secure, locked stud installation. Requires no special installation tools. Eliminates need for special thread fits to obtain secure locking action.

Materials: Alloy steel.

Sizes: No. 6 to 1/2 in. nominal diameters for nut-end threads; No. 10 to 5/8 in. nominal diameters for tap-end threads; Coarse and Fine series; Class 3. Various lengths.

Source: Fasteners Inc., East Boston, Mass.

Klincher Self-Locking Kapscrew

Form: One-piece, free-spinning type, self-locking capscrew with a double cap, a concave head, and a seating-type, all-metal, reusable collar. When bolt is seated to proper torque, collar compresses and inside of collar moves in to lock radially and axially on the screw shank and cap shoulder.

Design Features: Reusable. Concave cap permits the screw to elongate more under tensional load than conventional capscrew. Provides a high-strength self-locking capscrew which resists vibration loosening.

Materials: Steel, stainless steel, and other metals.

Sizes: No. 0-80 to 1/2 in. Head style is hex.

Source: Klincher Locknut Corp., Indianapolis, Ind.

(See Ad, Page 216)

KSM CD Weld Stud

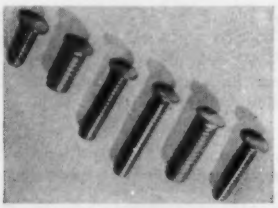
Form: Fully threaded stud with a broad flat weld base. Stud is welded to parent material by a semiautomatic capacitor-discharge welding process.

Design Features: Provides a permanent stud attachment that can be installed at high speed. Used primarily on thin-gauge sheet and shapes. Will not warp sheet metal nor damage stainless and enameled or plastic finishes.

Materials: Aluminum, stainless steel, brass, mild steel, and copper.

Sizes: No. 6 to 1/4 in. nominal diameters; NC threads. Lengths from 1/4 to 3 in.

Source: KSM Products Inc., Moorestown, N. J.



KSM Weld Stud

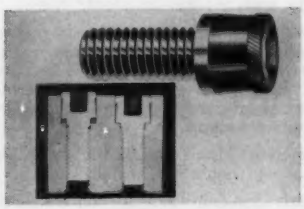
Form: Standard threaded stud with a solid flux tip. Stud is welded to parent material by a semiautomatic electric arc welding process.

Design Features: Provides a permanent stud attachment that can be installed at high speed. Flux tip can be used as center punch location point.

Materials: Low-carbon mild steel, and stainless steel.

Sizes: 1/8 to 1 1/8-in. weld base diameters. Lengths from 3/16 to 36 in. Standard NC threads. Styles include fully or partially threaded bodies.

Source: KSM Products Inc., Moorestown, N. J.



Led-Lok Cap Screw

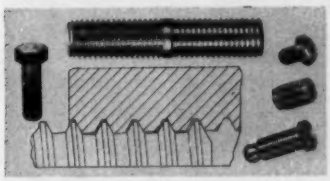
Form: Preassembled socket cap screw and lead washer. External surface of socket head has reverse taper with smallest diameter at top. As screw is tightened, washer extrudes into cavity along the sides of socket head formed by tapered shape. Wedge-shaped lead ring thus produced locks screw in place.

Design Features: Provides heavy-duty, flush-mounted locking fastener. Reusable when lead washer is replaced. Wedge-shaped lead ring provides fluid-tight seal around head. Locking action resists vibration.

Materials: Cap screw is heat-treated alloy steel.

Sizes: No. 4 to 1½-in.; NC and NF threads; Class 3.

Source: Safety Socket Screw Co., Chicago, Ill.



Lok-Thred Fasteners

Form: Externally threaded fasteners employing modified Unified thread form for prevailing-torque locking action. Thread form is used with socket having standard tapped threads. Modified thread has same 60-degree flank angle as American National thread but employs larger root diameter and a wider root surface which is tapered 6 degrees. Mating thread is reformed slightly in engagement, making possible locking on root along full length of contacting modified thread form. Metal of socket thread is placed under high compressive prestress.

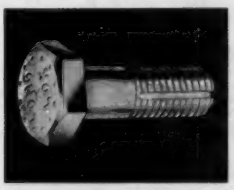
Design Features: Reusable. Provides control of installation torque. Mating thread can be formed with standard tools. Maintains secure locking action, which is improved by work load and vibration. Positive metal-to-metal contact of thread surfaces aids sealing action. Especially suited for use in light metals.

Materials: All standard metals for threaded fasteners.

Sizes: No. 6 to 1-in.; Coarse and Fine threads. Fastener types include bolts, screws, studs, and set screws.

Source: Lock Thread Corp., Detroit, Mich.

(See Ad, Page 212)



Long-Lok Screw

Form: Single-unit, prevailing-torque type self-locking screw. Plastic or metallic insert mounted in axial groove in threaded surface wedges screw threads against mating threads to develop firm locking grip.

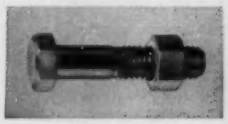
Design Features: Reusable. Can be used as an adjusting device. Locking action resists loosening effect of vibration. Can be readily adapted for low, medium, or high temperature conditions by varying insert material. Insert helps to prevent leakage of fluid under pressure along threads.

Materials: Screw body is steel, stainless steel, brass or aluminum; insert is Plaskon, Kel-F, stainless steel, or copper.

Sizes: No. 00 to 1-in. nominal diameters; Coarse and Fine threads. Various lengths. Body styles include all standard head types and driving recesses.

Source: Long-Lok Corp., Santa Monica, Calif.

(See Ad, Page 218)



Machine-Bolts

Form: Standard headed and threaded bolts for use in through holes with hex, square, or other appropriate mating nuts.

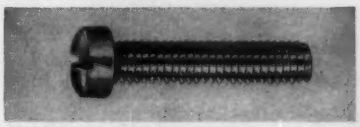
Design Features: Used for general-purpose fastening in all types of machinery and equipment. Hex-head bolts can be obtained in regular type for normal service or in heavy type for heavy loads and holes with large clearances.

Materials: Steel, brass, aluminum, stainless steel, and other materials.

Sizes: No. 10 to 4 in. nominal diameters; Coarse, Fine and 8-thread series; Class 2A. Body styles include square, round, and countersunk head as well as regular, semifinished, and finished regular and heavy hex head.

Source: *American Standard Round Head Bolts*—ASA B18.5-1952; American Standard *Square and Hexagon Bolts and Nuts*—ASA B18.2-1955. Photo, courtesy Standard Screw Co., Bellwood, Ill.

(See Ads, Pages 210, 220)



Machine Screws

Form: Standard-purpose, headed and threaded screw fastener. End of threaded shank is usually plain sheared, not pointed. When supplied with square nut, a machine screw becomes a stove bolt.

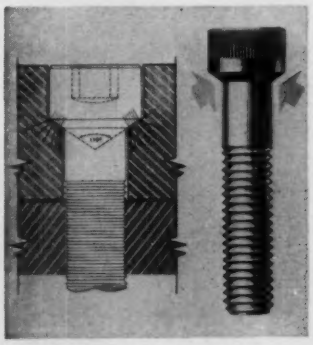
Design Features: Used for general-purpose fastening in tapped holes.

Materials. Steel, brass, aluminum, stainless steel, and other materials.

Sizes: No. 0 to ¾-in. nominal diameters; Coarse and Fine threads; Class 2A. Lengths from ⅛ to 3 in. Head styles include round, flat, oval, fillister, truss, binding, pan, and hex. Driving recesses include slotted, Phillips, Reed-Prince, and others.

Source: American Standard Slotted and Recessed Head Screws—ASA B18.6-1947. Photo, courtesy H. M. Harper Co., Morton Grove, Ill.

(See Ads, Pages 200, 201, 202, 203, 208, 210, 213, 214, 216, 218, 219, 220, 221)



Mac-it IB Cap Screw

Form: Standard socket-head cap screw with modified 118 deg tapered bearing surface under the head. Screw is assembled in stepped hole with mating tapered surface at step.

Design Features: Provides greater under-head area than conventional cap screw. Standard 118 deg drill matches angle of tapered bearing surface. Does not require counterboring; both holes can be drilled in one operation with step drill. Provides flush-mounted self-aligning fastener with high-torque capacity.

Particularly suited for use in soft materials, thin sections, and severe-duty applications where maximum tightening torque must be developed. Increased bearing surface and wedge action of tapered contact surfaces under compression load provide strong locking action and valve-type sealing.

Materials: Heat-treated alloy steel.

Sizes: No. 4 through 1½-in. nominal diameters; UNC or UNF threads; Class 3A. Lengths from ⅛ through 12 in. Head style is hex socket.

Source: Mac-it Parts Co., Lancaster, Pa.

(See Ad, Page 199)

McCormick-Selph Explosive Bolt

Form: All-metal bolt with provisions for integral or separately installed high-explosive charge. For maximum safety, bolt body is assembled first into the structure to be operated and then is armed by installing the high-explosive charge. Detonation of the explosive produces a high intensity short duration shock wave in the metal bolt. Subsequently, rarefactions of the tensile pulses are produced from the exterior surfaces. When these two tensile pulses collide, the bolt is fractured along the collision surface only. Position of the point of failure is accurately predetermined by controlling the properties of the bolt and charge.

Design Features: Fastener performs bolt-holding function and can still be broken at a predetermined point by an electrically

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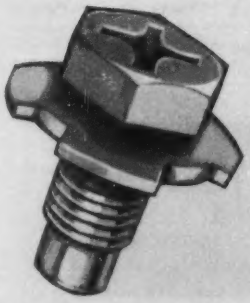

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Circle F-56 on Page 97

actuated charge. Unit is not sensitive to pressure, temperature, or vibration and shock loads. Safety is increased since explosive cartridge may be installed after bolt is assembled. Produces accurate, positive separation.

Materials: High-tensile steels.

Sizes: All standard bolt sizes and shapes. Bolt types include fragmenting and nonfragmenting designs.

Source: McCormick-Selph Associates, Hollister, Calif.

Metallic Drive Screws

Form: Type U American Standard tapping screw. Shank has multiple thread with large helix angle and flat dog point. Screws form mating thread when driven into prepared hole under pressure. Thread-forming action under pressure develops a strong locking grip.

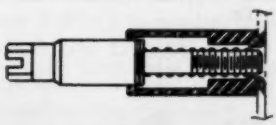
Design Features: Can be driven with hammer. Develops high holding power under tension and shear loading and will withstand severe vibration. Used as permanent fastener in heavy-gage sheet metals (0.060 to ½-in. thick), nonferrous castings, and plastics.

Materials: Case-hardened steel.

Sizes: No. 00 to ⅜-in. nominal diameters. Lenths from ⅛ to 1 in. Head style is round.

Source: *American Standard Slotted and Recessed Head Tapping Screws and Metallic Drive Screws*—ASA B18.6.4-1958.

(See Ads, Pages 198, 221)



Moran Captive Bolt

Form: Three-piece bolt assembly consisting of swaged-in-place sleeve, spring, and bolt. Bolt has threaded shoulder and shaft. Two threads in top of sleeve accommodate the threaded bolt shoulder. Two turns of bolt carry it through threads to become captive within sleeve, held in place by small tension spring.

Design Features: Subassembly is fastened tightly to major assembly by turning bolt into mating fastener until bolt tightens on shoulder in sleeve. Eliminates loose parts. Hexagonal, slotted head permits installation with screwdriver or wrench.

Materials: Sleeve is aluminum alloy, spring is spring-steel wire, and bolt is steel alloy.

Sizes: No. 8-32 NC threaded bolt with length from 1.6 to 4.0 in.

Source: Moran Co., El Segundo, Calif.

Moran Captive Screw

Form: Single-unit screw assembly consisting of Phillips-head screw and compression spring held captive in metal housing. Housing is pressed into prepared hole in panel or thin section and swaged in place.

Design Features: Subassembly is fastened tightly to major assembly by tightening screw into mating fastener until screw seats in housing. Screw retracts into housing when not in use to leave a flush mounting surface. Eliminates loose parts.

Materials: Housing is aluminum alloy, screw is 18-8 stainless steel, spring is Type 302 stainless steel.

Sizes: No. 4-40 or No. 8-32 screw. Screw extension when compressed is 0.25 in.

Source: Moran Co., El Segundo, Calif.

My-T-Grip Stud

Form: Standard threaded studs with insert-type head. Head, which has recessed, knurled grooves on external surface is pressed into suitable punched or drilled hole in sheet material, or molded into plastic sections. In pressing operation, stud is locked in place by cold flow of material between part and insert head.

Design Features: Provides strong, permanent, threaded stud attachment in thick or thin sheet metals or nonflowing plastics. Can be installed with standard hydraulic or pneumatic presses.

Materials: Mild steel or Type 303 stainless steel.

Sizes: No. 2-56 to No. 10-32 nominal diameters; Class 2A threads. Lengths are ¼ and ½ in. Material thicknesses of 0.030 in. up. Insert head styles include self-staking, shoulder, flush, and plastic types.

Source: My-T-Grip Mfg. Co., New York, N. Y.

Nelson Weld Studs

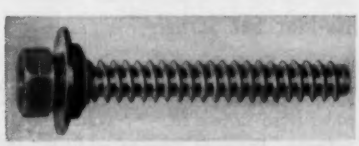
Form: Threaded and other type studs with weld tips containing granular flux. Stud is end-welded to the part by a semi-automatic electric-arc process.

Design Features: Eliminates need for tapped holes, hand welding, throughbolting. Provides a permanent stud attachment that can be installed at a rate of 6 to 8 per minute. Minimum thickness of material to which stud can be welded is 20 gage.

Materials: Low-carbon mild steel, stainless steel, or aluminum.

Sizes: Through 1-in. nominal diameters.

Source: Nelson Stud Welding Div., Gregory Industries Inc., Lorain, Ohio.



Neo-Bond

Form: Preassembled tapping screw and laminated sealing washer which consists of contoured molded neoprene washer bonded to conical dished metal body. Washer has tapered cross-section which is thicker at ID than at OD.

Design Features: Taper of contoured neoprene washer directs sealing action downward around screw shank when torque is applied. Neoprene seal is extruded into hole around screw shank. Sealing action is effective on flat, concave, or convex surfaces, and with misaligned holes. Creates a tight seal without extruding beyond washer face and without breaking or scuffing protective finishes. Can be used to provide a sealed joint, to protect surface finish, or to reduce noise and vibration in sheet-metal assemblies.

Materials: Screw is Type 305 stainless steel or carbon steel; metal washer body is steel, Type 302 or 430 stainless steel, or aluminum.

Sizes: No. 14, type A or B tapping screw threads. Lengths from ⅝ to 6 in. Head style is indented hex.

Source: Atlas Bolt & Screw Co., Cleveland, Ohio.

Nibscrew

Form: One-piece, all-metal, thread-cutting screw with nibs under head. Head takes up torque when nibs become seated.

Design Features: Provides resistance to stripping in applications which have little screw-thread engagement. Permits a broad range of driver settings.

Materials: Steel, aluminum, and stainless steel.

Sizes: No. 4 through ⅜ in. Various lengths. Head styles include hexagon washer, truss, pan, and others.

Source: Shakeproof Div., Illinois Tool Works, Elgin, Ill.

No-Mar Set Screw

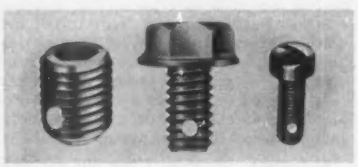
Form: Fully threaded screw with special nylon insert in tip for engagement with mating surface. Slotted or socket head provides flush surface fit.

Design Features: Permits positive locking action. Nylon insert takes shape of holding member and prevents marks or burrs.

Materials: Stainless steel with nylon insert.

Sizes: No. 2 to ¼-in. nominal diameters. Lengths from 5/32 to 5/16 in.

Source: PIC Design Corp., Subsidiary of Benrus Watch Co. Inc., East Rockaway, N. Y.



Nylok Fasteners

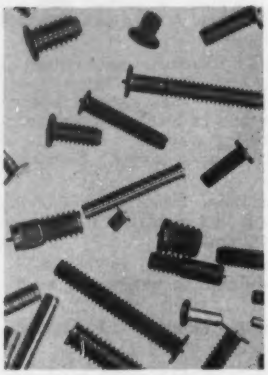
Form: Single-unit, prevailing-torque type, self-locking externally threaded fasteners. Resilient nylon plug in threaded shank wedges screw threads tightly against mating threads to develop positive locking action.

Design Features: Reusable. Effectiveness of locking action increases with use due to "plastic memory" characteristic of nylon plug. Can be used as adjusting device. Nylon plug acts as dam to prevent leakage of fluid along threads. Working temperature range is −70 to 250 F.

Materials: Carbon steel, stainless steel, aluminum alloy, brass or bronze.

Sizes: No. 2-56 and larger; Commercial and aircraft grade threads. Body types include bolt and machine screw, socket-head cap screw, set screw and others.

Source: The Nylok Corp., Paramus, N. J.



Omark Weld Studs

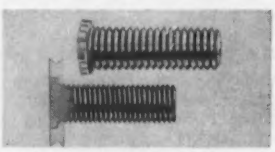
Form: Standard threaded and unthreaded studs with special weld tip. Studs are end welded to the workpiece by a stored-energy process that produces instantaneous heat at the welding point. Electrical energy (dc) is stored in capacitors and then released to produce a welding arc.

Design Features: Provides a permanent stud attachment that can be installed at high speed. A strong weld is formed without a fillet at the weld joint. Adjacent surface and opposite side of workpiece are not marred or burned by the welding process, even if plated, painted, or enameled.

Materials: Stainless steel, mild steel, or aluminum.

Sizes: 0.060 to 5/16-in. nominal diameters.

Source: Omark Industries Inc., Cincinnati, Ohio.



Pem Self-Clinching Stud

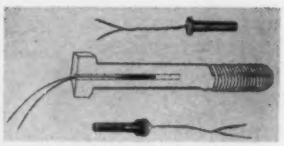
Form: Standard threaded stud with self-clinching head. Studs are pressed into prepared hole. Pressing operation embeds head projections of studs into part. Displaced metal flows smoothly and evenly around back-tapered section and annular groove on head to lock stud securely in place.

Design Features: Provides a secure, locked, flush, head-stud installation. Develops high torque and push-out resistance. Can be adapted to high-speed assembly methods. Suitable for use in panels of cold-rolled steel, brass, copper, aluminum alloys, and similar materials with thicknesses from 0.040 in. up.

Materials: Steel and 305 stainless steel.

Sizes: No. 4 to 5/16 in; Coarse and Fine threads. Lengths from ¼ to 1½ in.

Source: Penn Engineering & Mfg. Corp., Doylestown, Pa.



Pic Load-Sensitive Screw

Form: Standard headed and threaded cap screw, or bolt, with special resistance-type strain gage potted axially at center of shank. Tension or compression of fastener is sensed by strain gage and transmitted to a calibrated potentiometer, permitting direct measurement of actual working loads.

Design Features: Provides accurate (±1 per cent) measurement of actual tension or compression loads on bolt at any time during assembly or while in service. Permits dynamic measurements as well as periodic inspection tests. Can be used to equalize load distribution in multiple bolt arrangements, to avoid excessive tightening loads, to assure proper loading in highly stressed fasteners, or to serve as a load transducer for control or protection of machinery. Standard maximum operating temperature is 180 F.

Materials: Steel.

Sizes: ⅜ to 1-in. nominal diameters; Coarse and Fine threads. Lengths from 1¾ to 8-in. Body styles include hex and socket-head cap screws.

Source: Polyphase Instrument Co., Bryn Mawr, Pa.

Place Bolt

Form: One-piece, free-spinning type, self-locking bolt. Hex head has six slots in upper surface and circular recess in bottom side adjacent to shank. Elastic flexing of head when tightened against rigid seat develops secure spring-locking action.

Design Features: Reusable. Spring action of head greatly increases bolt's overall elastic elongation. Maintains sufficient tension even after considerable embedding of bolt head and settling of joined surfaces. Provides high resistance to loosen-

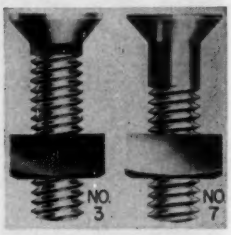
ing by vibration and minimizes fatigue failure, particularly in short bolt lengths. Can be readily adapted to cap screw applications.

Materials: Carbon or alloy steel.

Sizes: ¼ to 1¼-in.; Coarse and Fine threads. Various lengths. Head style is hex.

Source: Produced under license by several manufacturers. Photo, courtesy, National Screw & Mfg. Co., Cleveland, Ohio.

(See Ad, Page 212)



Plow Bolts

Form: Standard threaded bolts with special flat countersunk heads. Most widely used are No. 3 and No. 7 head types. No. 3 type has square neck; No. 7 type has reverse key on countersunk surface. Square nuts are generally employed for assembly and bolts are mounted in prepared holes to fit flush with part surface.

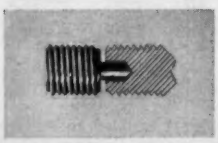
Design Features: Used primarily in farm equipment and construction machinery. No. 3 bolt can be used in steel parts where holes are either dry-sand or green-sand cored, or punched. It is not well suited for use in thin materials, or close to an edge because of head construction. No. 7 bolt may be used in steel or cast parts, and in thinner sections than No. 3. Key on No. 7 head may be located opposite a narrow edge to avoid strength reduction at that point. Key assures proper orientation of bolt in reassembly. No. 7 bolt provides neat appearance in assembly and is particularly suited for applications where scouring of the head in service occurs.

Materials: Low and medium-carbon and alloy steel.

Sizes: 5/16 to 1 in. nominal diameters; Coarse threads; Class 2A. Lengths from ¾ to 6 in. Body styles include several regular and repair types.

Source: *American Standard Plow Bolts* —ASA B18.9-1958. Photo, courtesy Bethlehem Steel Co., Bethlehem, Pa.

(See Ad, Page 210)



Point-Lok Fastener

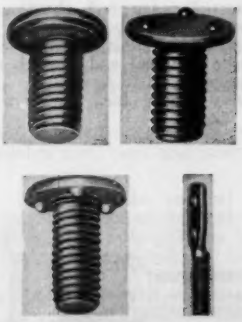
Form: Short, headless, screw body with projecting pointed shank of reduced diameter. Screw is used with a standard socket set screw. Pointed shank is driven down into socket to lock set screw in place.

Design Features: Provides strong holding action but is easily removable. Can be used as an adjusting screw. Does not damage set-screw sockets.

Materials: Steel, alloy steel, and stainless steel.

Sizes: No. 4 to ¾ in. nominal diameters. Body styles include slotted headless, hex, and fluted socket.

Source: Set Screw & Mfg. Co., Bartlett, Ill.



Projection Weld Screws

Form: Screw with flat-sided round or spade head having weld projections on one surface. Screw is projection welded in place on part surface.

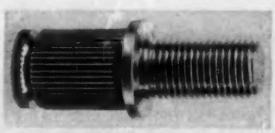
Design Features: Provides a permanent fixed screw attachment for metal parts. Adaptable to high-speed assembly methods. Type with projections under head is mounted in prepared hole and is used to provide a self-locating through bolt where a flush surface is required for attachment of mating parts. Type with ring projection under head is used in the same manner where hermetic seal or stronger weld is required. Type with projections on top of head eliminates need for drilling or punching of mounting holes and is used where a smooth outside surface is required for appearance purposes. Type with spade head is used where threaded section is required on end of sheet. Axis of the thread is offset from plane of joint.

Materials: Low-carbon or stainless steel.

Sizes: No. 6 to ½ in., Coarse or Fine threads. Various lengths.

Source: Information and photo, courtesy The Ohio Nut & Bolt Co., Berea, Ohio.

(See Ads, Pages 212, 217)



Push-lock Stud

Form: One-piece, all metal stud insert. Shoulder separates standard threaded stud member from insert body which has straight knurls on external surface and special spreader section at blind end. Insert body is pressed into drilled or molded hole to seat shoulder. Knurls grip wall of hole to prevent rotation. When blind end contacts bottom of hole, spreader section expands and engages hole wall to lock stud against pull out.

Design Features: Provides a secure, locked stud attachment in molded-plastic, soft-metal, and wood parts. Can be installed with standard arbor or air press. Eliminates need for tapped holes or molded-in inserts.

Materials: Brass and aluminum.

Sizes: No. 2-56 to No. 10-32.

Source: Fastener Products Inc., Wilton, Conn.

Quickey Bolt

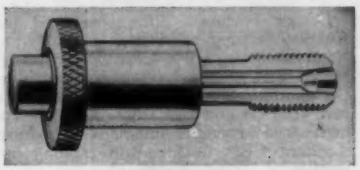
Form: Two-piece, all-metal bolt assembly consisting of small bolt attached to stamped metal tab. Tab snaps into keyhole-shaped cutout in stamped metal parts to hold bolt in place.

Design Features: Provides rapidly installed screw attachment for sheet-metal parts. Can be snapped into place at final assembly simplifying processing and handling of stamped parts.

Material: Steel.

Sizes: No. 10 to 5/16 in. nominal bolt diameters; Coarse and Fine threads. Grip lengths from 0.04 to 0.134-in. Body styles include several tab shapes.

Source: Carr Fastener Co., Div. of United-Carr Fastener Corp., Cambridge, Mass.



Quick-Release Bolt

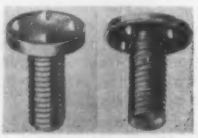
Form: Single-unit, all-metal, bolt assembly consisting of slotted, hollow threaded shank and a spring-loaded mandrel assembly. When button at end of bolt is depressed, the mandrel extends out of the threaded section, allowing the slotted sections to contract, disengaging threads from mating nut. Bolt may then be removed from the nut or tapped hole without turning.

Design Features: Provides a quick-release tension fastener that functions as a bolt in assembly. Nut can be wrenched to preload torque value to meet joint requirements. Mandrel maintains a positive locked-in contact between threads of tapped hole, or nut and bolt. Does not require special tools for assembly.

Materials: Stainless steel or alloy steel.

Sizes: 5/16, ⅜, and ½ in. nominal thread diameters. Various grip lengths.

Source: Avdel Inc., Burbank, Calif.



Rimguard Weld Screw

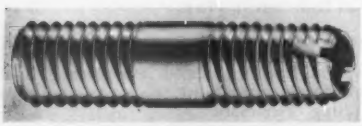
Form: Flat-top, round-headed screw with four weld projections for distribution of electric current, and protective rim on top or bottom side. Screw is projection welded in place on part surface. Rim limits, to a predetermined degree, the pressure applied to projections during fusing.

Design Features: Provides a permanent fixed screw attachment for metal parts. Provides proper diffusion of weld metals, and minimizes spatter and flash.

Material: Low-carbon steel.

Sizes: No. 6-32 to ⅜-16 nominal diameters; Class 2A threads, ¼ to 2-in. lengths.

Source: Parker-Kalon Div., General American Transportation Corp., Clifton, N. J.



Rosan Self-Tapping Stud

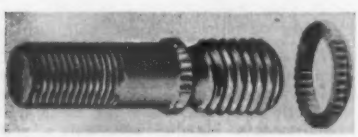
Form: Self-tapping, self-locking, size-on-size tap-end type stud. Tap-end thread has two thread-cutting slots and cuts its own mating thread as stud is driven into drilled hole. Threads beyond self-tapping portion produce an interference fit to lock driven stud securely in place.

Design Features: Eliminates need for separate tapping operation. Will fit into standard tapped holes, Class 3. Can be installed with standard power tools in plastic, aluminum, magnesium and some low carbon steels and cast irons. Adaptable to high-speed assembly methods. Produces standard Class 3 thread in tapping operation.

Materials: Heat-treated alloy steel.

Sizes: No. 6 to ½-in. nominal diameters; Coarse and Fine threads, Class 3A.

Source: Rosan Inc., Newport Beach, Calif.



Rosan Stud

Form: Two-piece, self-locking, tap-end type stud assembly consisting of stud and locking ring. Stud has serrated collar between tap and nut ends, and tap end threads have special pitch to produce slight interference fit with Class 3 tapped threads. Locking ring has serrated ID and OD. Stud is installed in tapped hole and locking ring is pressed into place, engaging inner serrations with collar and driving outer serrations into hole wall to produce a positive lock.

Design Features: Can be installed with standard tools. Locking action resists vibration, temperature variations, and high torque loads. Permits frequent assembly and disassembly.

Materials: Alloy steel.

Sizes: No. 6 to ¾-in. nominal diameters for nut end threads; Coarse and Fine Series; Class 3 A. No. 8 to ⅞-in. nominal diameters for tap end threads; special Coarse thread; Class 3A. Various lengths. Body styles include standard, molded pin, hydraulic, terminal and through types as well as others.

Source: Rosan Inc., Newport Beach, Calif.

Saf-Lok Cap Screw

Form: Preassembled socket cap screw and special grooved metal insert. As screw is tightened into counterbored hole, insert collapses, filling in counterbored hole to lock and seal screw head.

Design Features: Provides heavy-duty flush-mounted reusable locking fastener. Insert design permits greater tightening torque than for conventional cap screw. Locking action resists severe vibration and withstands high operating temperatures. Provides effective seal against leakage of liquids and gases. Insert stays in place when screw is removed.

Materials: Cap screw is heat-treated alloy steel; insert is brass, bronze, aluminum, or stainless steel.

Sizes: No. 8 to 1 in.; Coarse and fine threads; Class 3.

Source: Safety Socket Screw Co., Chicago, Ill.

Schweppe Stud

Form: Self-tapping, self-locking, tap-end type stud. Tap-end thread, which has two thread-cutting slots, cuts its own mating thread as stud is driven into drilled hole. Interference fit produced by thread-cutting action locks stud securely in place.

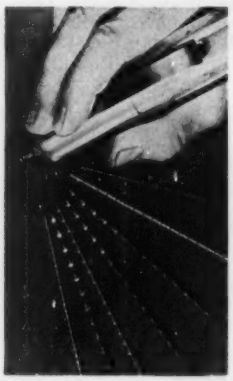
Design Features: Eliminates the need for separate tapping operation. Locking action resists vibration, stress reversals, and temperature change. Can be assembled with standard tools. Adaptable to high-speed assembly methods. Will fit into standard tapped holes.

Materials: Case-hardened alloy steel, high-temperature alloy steel, stainless steel, and nonferrous metals.

Sizes: No. 4 to 1-in. nominal diameters; all standard threads. Various lengths.

Source: Pheoll Mfg. Co., Chicago, Ill.

(See Ad, Page 221)



Screwstick

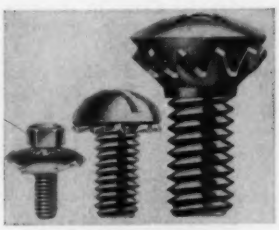
Form: One-piece multiple screw assembly for high-production fastening. Screws are joined in "sticks" of 24 to 60 by small necked sections between head and thread ends. They are fed automatically and torqued into position by pneumatic driver. When a screw is fully driven, necked section at head shears off to separate screw from stick.

Design Features: Permits rapid assembly of small screws at rates up to 1500 screws per hour. Driving torque is always applied to head of second screw. Necked section above head of each screw is designed to shear at predetermined torque value, assuring uniform tightening.

Materials: Brass, aluminum, nickel-silver, and steel.

Sizes: No. 0 to No. 6; Coarse and Fine threads. Lengths from 1/16 to 5/16-in. Head style is hex.

Source: American Screw Co., Willimantic, Conn.



Sems

Form: Preassembled rolled-thread screw and lock washer. Washer is held securely in position under screw head by expanded diameter of rolled thread.

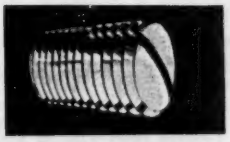
Design Features: Provides high-production locking fastener. Eliminates separate handling of screw and washer. Washer can rotate freely but can't drop off. Shifting of lock washer in tightening is minimized and thread damage due to canting of washer is avoided.

Material: Mild steel.

Sizes: No. 2 to ⅜-in.; Coarse and Fine threads. Screw and washer assemblies include a number of different standard combinations. Washer types include external, internal, countersunk, dome, dished, multiple-piece, and many others.

Source: Shakeproof Div., Illinois Tool Works, Elgin, Ill.

(See Ads, Pages 200, 211)



Setko Offset Set Screw

Form: Slotted, headless, prevailing-torque type self-locking set screw. Slotted sections are offset from true round to produce locking grip on mating threads when set screw is driven into tapped hole.

Design Features: Resists loosening under severe vibration and load conditions. Locking action is not affected by variations in tapped hole threads.

Materials: Cyanide-hardened steel.

Sizes: No. 4 to ¾-in. nominal diameters; Coarse and Fine threads. Lengths from 3/16 to 1-in. Point styles include cup, hanger, flat, half and full dog, cone, and pivot.

Source: Set Screw and Mfg. Co., Bartlett, Ill.

Setko Truncated Set Screw

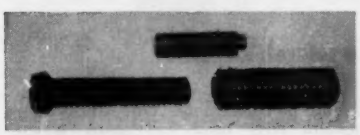
Form: Socket set screw with threads that are truncated on the root. Socket is one size larger than conventional set screw.

Design Features: Designed for applications where additional setting torque is required. Requires good tapped hole. Adaptable to high-speed assembly methods.

Materials: Steel and alloy steel.

Sizes: No. 4 to ¾ in. nominal diameters. Various lengths. Socket style is hex. Point styles include crip, flat, oval, cone, and half and full dog.

Source: Set Screw & Mfg. Co., Bartlett, Ill.



Set Screws

Form: Fully threaded screw with special pointed end for engagement with mating surface. It is usually employed in a through tapped hole and tightened to high setting torque value to provide maximum holding power.

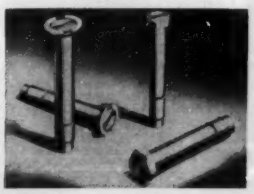
Design Features: Used for assembling parts to shafts or to hold parts in relative position to each other. Slotted and socket types provide a flush surface fit. Square head type requires no special wrenches or tools for assembly. Several point styles have been standardized: Half dog point is recommended for use in hardened members or where end of thread must be protected; flat point is used with parts requiring frequent adjustment or relocation, or where wall thickness is thin; cone point is used for setting machine parts permanently on shaft; oval point is used against a surface spotted to receive it, or against splined parts; cup point is perhaps most commonly used and is suitable for wide range of general-purpose applications.

Materials: Heat-treated carbon or alloy steel, stainless steel, brass, and other materials.

Sizes: No. 0 to 2 in. nominal diameters; Coarse, Fine and 8-thread series; Class 2A and 3A. Body styles include square head, headless slotted, and hex and fluted-types. Point styles include cup, flat, oval, cone, and full and half dog.

Source: *American Standard Hexagon Head Cap Screws, Slotted Head Cap Screws, Square Head Set Screws, and Slotted Headless Set Screws* — ASA B18.6.2-1956; *American Standard Socket Head Cap Screws and Socket Set Screws*— ASA B18.3-1954. Photo, courtesy Anti-Corrosive Metal Products Co. Inc., Castleton-on-Hudson, N. Y.

(See Ads, Pages 199, 201, 205, 215, 216, 221)



Sleev-Lock

Form: All-metal, preassembled unit for blind application, consisting of outer sleeve, nut, and inner-core bolt. Special attachment holds outer sleeve stationary while driving core bolt. This draws expandable nut up over end to knurled sleeve to clamp assembly together. To remove, drive is reversed to withdraw core bolt. Nut is pushed off end of sleeve which is then withdrawn.

Design Features: Sleeve and bolt are removable and reusable. Eliminates drilling to remove. Prevailing-torque type nut provides double-locking action when pulled over knurled sleeve. High strength and vibration resistant. Preload can be controlled in driving tool.

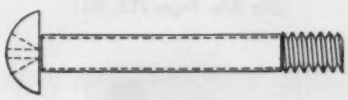
Materials: Titanium, and stainless and high-strength steels.

Sizes: 3/16 to ⅜-in. diameter. Various grip lengths. Available in countersunk flush and protruding hex steels.

Source: Standard Pressed Steel Co., Jenkintown, Pa.

Sleev-Scru

Form: One-piece, metal screw with an integral cladding of Mylar polyester film



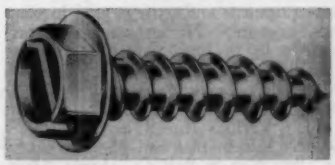
on the shank. Diameter of insulated shank is same as OD of threaded section.

Design Features: Provides electrical insulation between fastener and assembled parts. Eliminates insulating tube assemblies. Permits reduction in size and weight of overall assembly.

Materials: Screw body is steel, brass, or stainless steel.

Sizes: No. 1 to ¼-in. nominal screw diameters. Lengths from ⅛ to 3 in. Driving recesses include slotted and Phillips.

Source: Pylon Co. Inc., Attleboro, Mass.



Spee-D Screw

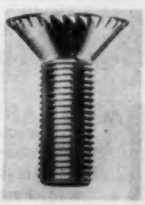
Form: Self-drilling sheet-metal screw with sharp pinch point and spaced tapping thread. Point pierces its own hole when pressed against sheet-metal surface and screw is driven into place like conventional thread-forming tapping screw.

Design Features: Eliminates separate hole-forming operation. Can be driven with hand or power tools. Suitable for sheet-metal thicknesses up to No. 18 gage (0.050 in.).

Materials: Heat-treated steel.

Sizes: No. 6 to No. 10 nominal diameters. Lengths of ⅜ or ½ in.

Source: Air Control Products Inc., Coopersville, Mich.



Spin-Lock Screw

Form: One-piece, all-metal locking screw. Ratchet-like teeth under head imbed in part surface when screw is tightened to provide firm locking grip.

Design Features: Provides a high-production locking fastener. Eliminates separate handling of screw and lock washer. Can be torqued to high tension. Holds tight under extreme vibration or changing temperature conditions. Construction of ratchet teeth permits easy assembly but develops high resistance to loosening. Surface locking action develops fluid-tight seal under head.

Materials: Carburized steel.
Sizes: No. 4 to ½-in.; Coarse and Fine threads. Lengths from minimum of twice screw diameter up.
Source: Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y.

(See Ads, Pages 212, 217)

Spotweld Screw

Form: Screw with flat, right-angle spade head. Head base is spot welded in place on part surface.
Design Features: Provides a permanent, fixed-screw attachment for metal parts. Adaptable to high-speed assembly methods. Can be spot welded in place with same equipment and settings used in component assembly. Narrow spade head permits use in confined areas and narrow channels.
Materials: Low-carbon steel.
Sizes: No. 6 to ⅜ in. Coarse and fine threads. Various thread lengths.
Source: Information and photo, courtesy The Ohio Nut & Bolt Co., Berea, Ohio.

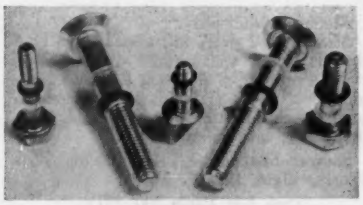
Spred-Lok

Form: Slotted, headless, prevailing-torque type, self-locking set screw. Slotted section of screw is spread slightly to produce a locking action.

Design Features: Reusable. Recommended for use in light metals and softer grades of steel. Locking action can be increased by rocking screwdriver back and forth to spread the slot.
Material: Steel.
Sizes: No. 4 to ¾ in. nominal diameters. Various lengths. Point styles include crip, flat, cone, oval, half and full dog.
Source: Set Screw & Mfg. Co., Bartlett, Ill.

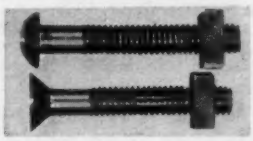
Sta-Seal Fasteners

Form: Single-unit, self-sealing screw or bolt with thin Teflon shim mounted between standard O-ring and groove on bottom side of head. When fastener is tightened, O-ring flows to provide fluid-tight seal under screw or bolt head. Teflon shim acts as a lubricant between screw head and O-ring.
Design Features: Reusable. Eliminates separate handling of screw and sealant. Prevents cold flow, galling, or cutting of seal ring without the aid of harmful lubricants. Design of O-ring groove permits metal-to-metal contact of faying surfaces and protects sealing element from damage by loads applied to fastener or extrusion in assembly or service.



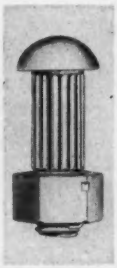
Materials: Screw or bolt is mild alloy steel, commercial brass, Type 431 stainless steel, or aluminum alloy; O-ring is synthetic rubber.
Sizes: No. 4 to ½ in., NC and NF threads. Lengths from 0.187 to 8.968 in.; grips from 0.062 to 8.187 in. Head styles include washer, hex, and 100 deg flat.
Source: Aero-Stat Co., Los Angeles, Calif.

(See Ad, Page 201)



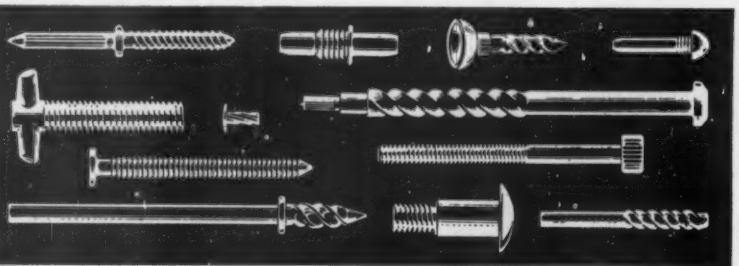
Stove Bolts

Form: Machine screw with square nut.
Design Features: Used for general-purpose fastening in through holes in light or moderately loaded applications such as electrical equipment, household appliances, toys, etc.
Materials: Steel, brass, aluminum, stainless steel and other materials.
Sizes: ⅛ to ½-in. nominal diameters; Coarse threads; Class 2A. Head styles include round, flat, oval, filister, truss, pan, and hex. Driving recesses include slotted and Phillips.
Source: Produced by several manufacturers. Photo, courtesy Bolt and Chain Div., Republic Steel Corp., Cleveland, Ohio.



Structural Rib Bolt

Form: All-metal, prevailing-torque type locking bolt assembly. Bolt consists of standard rivet head and shank which is axially ribbed at upper end and has standard thread to receive mating prevailing-torque locknut. Bolt is driven into prepared hole, causing triangular-shaped ribs to deform in a body-bound fit that locks bolt securely in place. Nut is then applied and wrenched tight.



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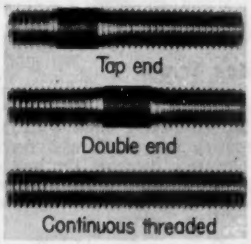
Circle F-57 on Page 97

Design Features: Develops high-force locking grip. Nut is reusable. Provides higher shear and bearing strength than equivalent power-driven rivets. Bolt is easily removed without damage to edges of hole. Can be assembled with hand hammer and wrench. Used in rugged, heavy-duty assemblies or structures where stress, shock, or vibration conditions are unusually severe.

Materials: Bolt is carbon manganese steel with minimum tensile strength of 70,000 psi; nut is open-hearth carbon steel with chrome vanadium steel locking pin.

Sizes: ⅜ to 1-in. nominal diameter; NC threads; Class 2. Lengths from 15/16 to 5⅜ in. Head styles include standard American Boiler Makers' Association button and countersunk.

Source: Automatic Nut Co. Inc., Lebanon, Pa.



Studs

Form: Standard headless, threaded fasteners. Gland or tap-end studs are threaded at one end for semi-permanent, interference fit in a tapped hole and at other end for assembly of standard nut. Length of thread on the nut end may vary but that of the tap end is usually fixed. Double-end studs are threaded at both ends for assembly with two standard nuts. They are usually symmetrical in design. Continuous-thread studs and stud for pressure-temperature piping are threaded from end to end.

Design Features: Tap-end studs are used where a semipermanent thread attachment is required. They frequently offer advantages in assembly, particularly in high-speed production line operations. Double-end studs are used primarily in flange joints, and similar applications where a double nut adjustment is required. Continuous thread studs are used for general-purpose fastening. Pressure-temperature piping studs are designed for use in high-temperature, high-pressure applications.

Materials: Steel, alloy steel, corrosion-resistant steel, brass, aluminum, and other materials.

Sizes: ¼ to 1½ in. nominal diameters; Coarse, Fine, and 8-thread series; Class of fit varies with stud type and thread function. Lengths from 1 to 6 in.

Source: Industrial Fastener Institute Standard. Photo, courtesy Bethlehem Steel Co., Bethlehem, Pa.

(See Ads, Pages 200, 202, 210, 214, 220)

Super-Strength Bolts

Form: High-strength, 12-point, external-wrenching bolt assembly. Bolt has large-radius, controlled root in thread to minimize stress concentrations. Twelve-point

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ALLOY STEEL SCREWS

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SOCKET HEAD CAP SCREW

The Mac-it IB (Improved Bearing) is a major advance in socket head cap screw design. The taper provides 17% more bearing surface without an increase in head size and produces 27% improvement in working efficiency. No indenting, fatiguing or splitting of mating parts even in soft materials or thin section assemblies.

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Available in both the 1936 Series and the new 1960 Series in alloy and stainless steel.

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Circle F-55 on Page 97

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METALS Brass, Steel, Stainless Steel, Monel, Nickel Silver, Aluminum, Silicon Bronze, Commercial Bronze.
FINISHES Nickel, Cadmium, Zinc, Brass, Bronze, Chrome, Parkerizing, Iridite, Blued.
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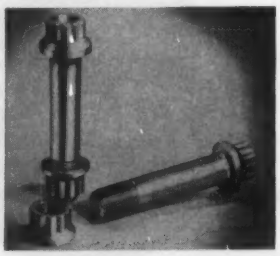
Circle F-61 on Page 97



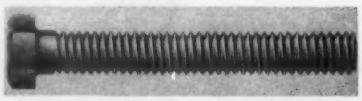
nut has standard threads and displaced collar to provide prevailing-torque locking feature.

Design Features: Tension bolt configuration has minimum tensile rating of 220,000 psi, shear bolt configuration has minimum tensile strength of 260,000 psi. Minimum double shear strengths reach 156,000 psi. Assemblies have high fatigue strength; endurance limits reach 110,000 psi for 8,000,000 load cycles in tension-tension fatigue testing. External wrenching, 12-point design of bolt head and nut permits extreme tightening to develop necessary high preloads. Miniaturized 220,000 psi series has reduced bearing areas for use in harder materials. Strength-weight ratios are comparable with strongest titanium bolts.

Materials: 5 per cent chromium hot-work die steel.

Sizes: No. 10 to 1½ in.

Source: Standard Pressed Steel Co., Jenkintown, Pa.



Tap Bolts

Form: Regular hexagon headed bolt with pointed end and fully threaded shank. Bolt is usually employed in tapped hole without nut.

Design Features: Used in applications with a tapped hole where through bolt, stud, or cap screw would be impractical.

Materials: Steel.

Sizes: ¼ to 1 in. nominal diameters; Coarse threads; Class 2 A. Lengths from ½ to 5 in.

Source: Industrial Fastener Institute Standard. Photo, courtesy Bethlehem Steel Co., Bethlehem, Pa.

Tapit

Form: Thread-forming tapping screw with a cuniform point that drills its own hole. Screw is power driven into light-gage sheet-metal.

Design Features: Does not require a spotting hole. Provides a rapidly installed fastener for sheet-metal parts. Serrated washer face acts as a brake on screw rotation to prevent stripping. Head size is the same for all thread sizes.

Material: Steel.

Sizes: No. 6 through No. 10 tapping threads. Head style is hex.

Source: Parker-Kalon Div., General American Transportation Co., Clifton, N. J.

Tensilock Screw

Form: One-piece, all-metal, free-spinning type, self-locking screw with flanged head. Bearing face of flanged head has ratchet-like teeth on outer rim and a circular groove in center. Teeth imbed in part surface when screw is tightened to provide a firm locking grip.

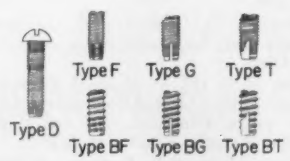
Design Features: Reusable. Provides a high-production locking fastener. Eliminates separate handling of washer and screw. Groove in flange face increases diaphragm action to help maintain residual tension in the fastener. Tensile strength is 125,000 psi. Teeth are angled on the advancing side to facilitate tightening, but are vertical on the back side to resist loosening. Torque required to loosen screw is 150 per cent of application torque. Locking action resists severe vibration or cyclic heating and cooling. Develops high tension-to-torque ratio. Wide flanged head spans oversize clearance holes.

Material: Carburized steel.

Sizes: No. 6 to ⅜ in. Lengths from twice screw diameter up. Head styles include all standard forms except flat.

Source: Russell, Burdsall & Ward Bolt and Nut Co., Port Chester, N. Y.

(See Ad, Page 217)



Thread-Cutting Tapping Screws

Form: Types BF, BG, BT, D, F, G, and T American Standard tapping screws. Types BF, BG, and BT have spaced threads, blunt point. Types D, F, G and T have machine-screw threads, blunt point. All threads are fully hardened and each screw type has one or more cutting edges and chip cavities located in tapered entering threads. Screws cut close-fitting mat-

ing thread when turned into prepared hole.

Design Features: Used for application in materials where disruptive internal stresses are not desirable, or where excessive driving torques are encountered with thread-forming screws. Screws remove rather than displace material in forming mating thread. Types BF, BG, and BT are used in comparatively thin sections and bosses of friable and brittle plastics, and also in diecastings and other nonmetallic compositions. They require minimum driving torque, resist stripping out, and can be used with thin wall sections because of low side pressures developed. Types D, F, G, and T screws are used in sheet metal, structural steel, cast iron, diecastings, brass and bronze forgings, and plastics. They provide a close-mating thread fit that resists loosening by vibration or temperature variation.

Materials: Case-hardened steel.

Sizes: No. 0 to ½ in. nominal diameters. Lengths from ⅛ to 1½ in. Head styles include round, flat, oval, fillister, truss, pan, hex, and hex washer. Driving recesses include slotted, Phillips, and Reed-Prince.

Source: *American Standard Slotted and Recessed Head Tapping Screws and Metallic Drive Screws*—ASA B18.6.4-1958.

(See Ads, Pages 200, 202, 211, 212, 221)

Type A Type B Type BP Type C

Thread-Forming Tapping Screws

Form: Types A, B, BP, and C American Standard tapping screws. Type A has spaced thread, gimlet point; Type B has spaced thread, blunt point; Type BP has spaced thread, cone point; and Type C has machine-screw thread, blunt tapered point. Screws form chip-free mating thread when turned into prepared hole. Thread-forming action draws parts together and develops secure locking grip.

Design Features: Used in materials where large internal stresses are permissible or desirable to increase resistance to loosening. Types A and B are the so-called sheet-metal screws. Type A is used to join light-gage sheet metals (0.015 to 0.050-in. thick) and certain nonmetallic compositions. Type B is heavier duty screw for use in light and heavy sheet metals (0.015 to 0.200-in. thick), structural sections, nonferrous castings, plastics, and other nonmetallic compositions. Type BP is same as Type B but has cone point to facilitate assembly where holes are misaligned. Type C is used in applications where machine-screw tapping thread is desired. It usually requires higher driving torque than spaced-thread types but can be readily assembled to parts with standard internal threads.

Materials: Case-hardened steel.

Sizes: No. 0 to ½-in. nominal diameters. Lengths from 3/16 to 2 in. Head styles include round, flat, oval, fillister, truss, pan, hex, and hex washer. Driving recesses

25 years of progress in tiny parts

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☐ SIMPLIFY ASSEMBLY
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Cap Nuts
Thumb Nuts

NOW! NYLON SCREWS AND NUTS
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MACHINE SCREWS from miniature #0 thru ¼" in wide range of lengths and head types. Also SET SCREWS. NUTS from #2 thru 5/16". GRC's wide selection of molded fasteners available from stock. Samples sent immediately.

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Die cast or molded in one high speed automatic operation, GRC's exclusive methods assure uniformity, smooth, rustproof and corrosion resistant surfaces and the lowest possible cost. New kinds of fasteners never before available . . . modifications in stock fasteners for specialized use . . . infinite variety in styles, types and sizes, have been made possible by GRC's special automatic die casting and molding machines.

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MOLDED NYLON
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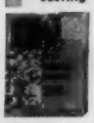

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Circle F-62 on Page 97

STA-SEAL

THE PERFECT SEAL under ANY conditions

The revolutionary new STA-SEAL FASTENER is adaptable for use wherever safe, sure sealing is required.

POSITIVE SEALING under the widest range of temperatures & in contact with most known fluids and gases.

APPROVED FOR MILITARY USE

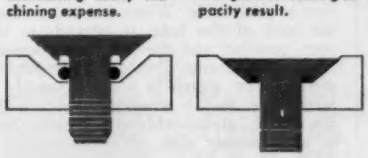
This new self-sealing concept is now available in standard AN and NAS lengths, grips & threads, and comes in every popular head style. Our engineers are ready to prepare any fastener to meet particular specifications.

A WASHER OF TEFLON
Set in a specially designed "o" ring groove in the completely cold-headed fastener absorbs friction & abrasion.

Patent No. 2,752,814— other patents pending.

Each fastener is a complete unit, with "o" ring and Teflon washer. Each may be used time and again without damage eliminating costly machining expense.

The Teflon washer sits in the specially designed "o" ring groove cold-headed in the fastener. Greater tensile strength and greatest sealing capacity result.



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Circle F-63 on Page 97

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Capacity is 1/16" through 1-1/8" diameters, in Steel, Brass, Stainless, Fibre, Plastic or Nylon. Constant floor inspection and final inspection to AQL standards assures you top quality parts on every shipment.

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25,000 square feet of warehouse space stocked with standard fasteners assures you immediate delivery. Your fastener is always "in stock at Abbott."

COLD HEADING

If you are now using a screw machine part—let us check it and make suggestions for fabricating the part by the less expensive cold headed method. We manufacture Phillips Thread Cutting Screws, Wire Forms, Studs and Headed Rods.

STAMPINGS

Wide range of press sizes up to 100 tons plus complete tool and die facilities and secondary equipment (forming, piercing, swedging, bending or drilling) mean bigger savings for you.

JUST OFF THE PRESS

Cat. No. 1060 lists standard fasteners in stock, tells about mfg. facilities.

Price List 106SP covers socket set screws — an Abbott money-saving special.

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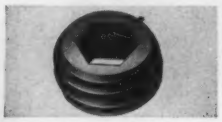
Circle F-59 on Page 97

include slotted, Phillips, and Reed-Prince.

Source: *American Standard Slotted and Recessed Head Tapping Screws and Metallic Drive Screws*—ASA B18.6.4—1958.

(See Ads, Pages 200, 212, 214, 221)



Through-Socket Set Screws

Form: Short-body set screw with socket extending completely through body.

Design Features: Can be used separately as a set screw or with another headless set screw as an internal "locknut" to prevent loosening under severe speed and vibration conditions. Adaptable to high-speed assembly methods.

Materials: Heat-treated alloy steel.

Sizes: No. 4 through 1-in. nominal diameters; Coarse or Fine threads; Class 2A and 3A. Lengths from 1/8 to 1-in. Body styles include hex and fluted sockets.

Source: (Thru-Broached Socket Set Screw) The Bristol Company, Waterbury, Conn.; (Hollow Locking Screw) Mac-it Parts Co., Lancaster, Pa. Photo, courtesy Mac-it Parts Co.

(See Ad, Page 199)

Thumb Screws

Form: Standard threaded screw with oversize knurled, spade or "wing" head for hand assembly.

Design Features: Provides a large finger-grip surface to facilitate tightening or removal. Particularly suited for knock-down assembly applications, or where frequent screw adjustments are required.

Materials: Steel, brass, aluminum, and other materials.

Sizes: No. 4 to 3/8 in. nominal diameters; Coarse and Fine threads. Various lengths.

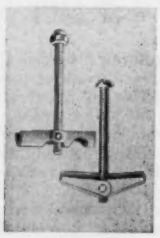
Source: Produced by several manufacturers. Photo, courtesy The H. M. Harper Co., Morton Grove, Ill.

(See Ads, Pages 201, 213)

Toggle Bolt

Form: Single-unit, all-metal bolt assembly consisting of a bolt with a folding wing member threaded on the end. The wing is folded in and the bolt inserted into a blind hole. When the wing clears the back of the hole, it expands to the open position and the bolt is tightened.

Design Features: Provides a convenient method for attaching parts through a blind hole. Bolt is threaded along its entire length, giving wide grip length range in one fastener size.



Material: Steel.

Sizes: 1/8 to 1/2 in. nominal bolt diameters. Lengths from 2 to 6 in. Wing styles include spring, gravity, and plumber's-toggle types. Bolt styles include round or flat head, and headless.

Source: Produced by several manufacturers. Illustration, courtesy Ackerman-Johnson Co., Chicago, Ill.

Topseal Fastener

Form: Preassembled, special, self-tapping or sheet-metal screw or bolt and Weath-R-Seal washer of metal and neoprene composition. When fastener is tightened against part surface, bonded neoprene composition extrudes to form water-tight seal.

Design Features: Reusable. Neoprene composition seals both at washer edge and screw shank. It is protected from damage in driving by bonded metal backing which provides "free spinning" surface upon which fastener head is free to turn. Adaptable to high-speed assembly methods. Resists vibration. Can be used with corrugated surfaces. Eliminates separate handling of screw and sealant. Forms water-tight seal under 60 lb pressure when tightened to minimum of 25, or maximum of 175, in.-lb torque.

Materials: Screw or bolt is usually steel or special corrosion-resistant material; bonded metal washer backing is galvanized steel aluminum, corrosion-resistant steel, or vulcanized fibre.

Sizes: All standard screw threads. Washer OD from 3/8 to 3 in. Body styles include all standard bolt and screw types.

Source: Fabricated Products Co., West Newton, Pa.

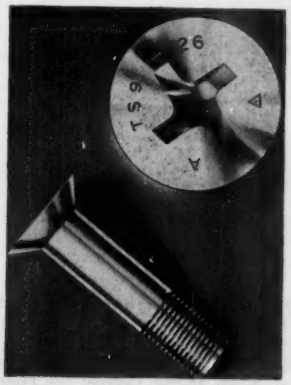
Torq-Set

Form: High-strength, flat-head machine-bolt with forged internal driving socket of nonsymmetrical form. Bolt is tightened with conventional manual or power-operated driving tools using a special high-strength bit.

Design Features: Permits development of extreme tightening torques. Provides high impact resistance. Can be adapted to high-speed assembly methods. Driving socket design simplifies tooling requirements and permits easy disassembly. Used primarily where high preload is required.

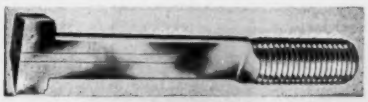
Materials: Alloy steel.

Sizes: No. 4 to 5/8-in. nominal diame-



ters; Coarse and Fine threads. Various lengths.

Source: American Screw Co., Willimantic, Conn.



Tru-Load Bolt

Form: Standard headed and threaded bolt, or capscrew, with unstressed metal reference pin mounted in axial hole in center of shank. When bolt is unloaded, end of pin is flush with upper surface of bolt head. As bolt is tightened, elongation of shank changes the relative position of the two reference surfaces, providing a direct measure of the actual tensile stress on the bolt shank.

Design Features: Provides accurate measure of actual load on bolt at any time during assembly. Bolt loads can be readily measured using a direct reading stress gage. Used primarily in highly stressed bolt applications where close control of preload is essential assembly requirement.

Materials: All standard materials for threaded fasteners.

Sizes: All standard screw thread sizes.

Source: Precision Threaded Products Div., The Bland Burner Co., Hartford, Conn.

Tuff-Tite Fasteners

Form: Preassembled screw or bolt and molded neoprene washer. Screw, or bolt, is made with special formed undercut washer head. Neoprene washer has tapered cross section which is thicker at ID than at OD.

Design Features: Built-in washer construction reduces possibility of leakage, and offers appearance advantages. Undercut in washer head of screw traps and controls expansion of washer, preventing exposure of neoprene and insuring positive seal when screw is tightened. Sealing action is effective on flat, concave, or convex surfaces, and with misaligned holes. Can be used to provide a sealed joint, to protect surface finishes, or to reduce noise and vibration in machine

PARTS PRODUCED BY HARPER FLO-FORM

are cold formed or hot forged from bar and wire stock with practically no waste of metal. In a completely integrated plant, Harper's controlled processes—from billet to bolt—assure quality and uniformity resulting in a better part at important savings. With an inventory of over 150,000,000 pieces in more than 100 alloys—including many specials illustrated above—Harper can fill your order today. Consult the Yellow Pages for the name of your nearest Harper Distributor.

Write today on your letterhead for FREE copy of Harper's FLO-FORM Brochure

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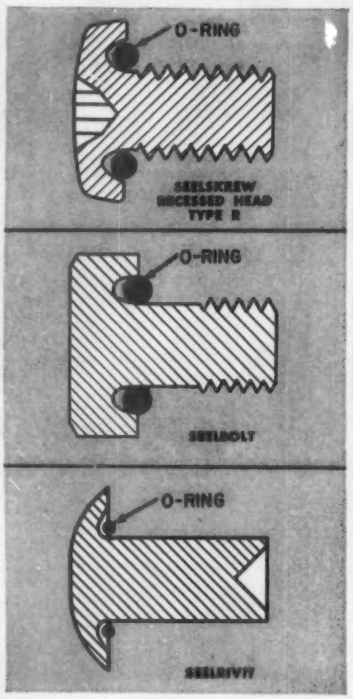
8224 Lehigh Ave. • Morton Grove, Ill.

Circle F-60 on Page 97

HARPER

SEELSKREWS*
SEELBOLTS*
SEELRIVITS*
High Pressure Self-Sealing
FASTENERS



- Removable and static self-sealing screws, bolts and rivets.
- These industrial fasteners meet all applicable military specifications.

SEND FOR CATALOG 359A-15 *describing items above, also seals for switches, shafts, circuit breakers, indicator lights and other electronic components.*

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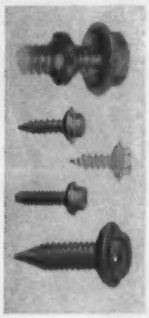
Designers and Manufacturers of
HIGH PRESSURE STATIC AND MOVABLE SEALS
Hexseals* • Seelskrews* • Seelbolts* • Seelrivits*

Circle F-54 on Page 97



assemblies. Application temperature range is −65 to 250 F.

Materials: Screw is corrosion-resistant steel, carbon steel, alloy steel, or nonferrous material, such as aluminum or copper; washer is carbon black filled neoprene.

Sizes: All standard threads. Screw types include tapping and drive, machine and others.

Source: Townsend Co., Engineered Fasteners Div., Ellwood City, Pa.

(See Ad, Page 212)

Type L Tapping Screw

Form: Combination thread-cutting and thread-forming tapping screw designed primarily for use in nylon. Lead threads perform limited thread-cutting function to facilitate thread-forming action of full diameter threads.

Design Features: Primarily suited for use with nylon parts which must be disassembled for service. Can be removed and replaced in nylon without stripping or galling. Provide a close-mating thread fit that resists loosening by vibration or temperature variation.

Material: Case-hardened steel.

Sizes: Standard tapping-screw diameters and lengths.

Source: Parker-Kalon Div., General American Transportation Co., Clifton, N. J.

(See Ad, Page 211)

Ultra-High Temperature Bolts

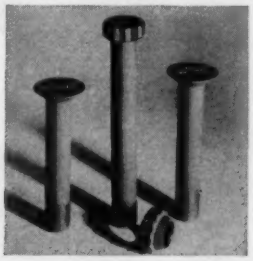
Form: High-strength, 12-point external wrenching bolt assembly for temperatures from 900 to 1600 F. Mating nut is one-piece, metal, prevailing-torque locking type. Bolt thread has special large radius root.

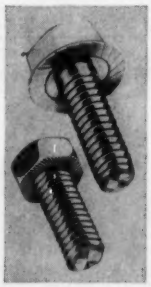
Design Features: Reusable at high temperatures. Nut is designed to minimize galling and seizing problems at elevated temperatures. Bolts are rated at 220,000 and 260,000 psi minimum tensile strength. One series can develop 200,000 psi tensile strength at 900 degrees. 1600 F series develops 135,000 psi tensile strength at 1200 F, and 85,000 psi at 1600 F. Minimum stress-rupture life is 100 hours at 1500 F, and 10 hours at 1600 F for sustained load of 30,000 psi.

Materials: 5 per cent chromium die steel, A-286, M-252, Udimet 500, Hastelloy, Waspalloy, and other superalloys.

Sizes: No. 6 to 1½ in.

Source: Standard Pressed Steel Co., Jenkintown, Pa.





Whiz-Lock Screws

Form: One-piece, free-spinning type, self-locking screw. Ratchet-like teeth on the convex bearing surface of the screw head grip part surface when screw is tightened to provide firm locking action.

Design Features: Reusable. Locking element is contained within the head of the screw with no projecting teeth. Eliminates separate handling of screw and lockwasher. Requires more torque to remove than to apply. Directional shape of teeth permits torquing to high tension. Tooth action is burr free. Resistant to vibration.

Materials: Case-hardened steel.

Sizes: No. 6 to ⅝ in., Class 2B threads. Head styles include hex and hex flange.

Source: MacLean-Fogg Lock Nut Co., Chicago, Ill.

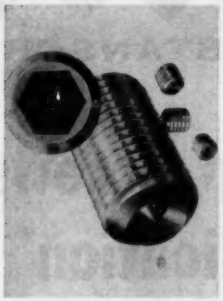
W-Point Set Screw

Form: Standard hex socket set screw with cone point centered in a cup edge. Cone point engages working surface before cup edge.

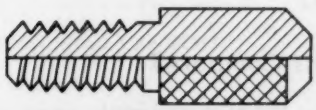
Design Features: Provides positive frictional contact of flanks of cup with working surface. Tracks evenly with a well-defined groove. Cone point acts as a fixed point to minimize the tipping effect of key tightening

Material: Alloy steel and stainless steel.

Sizes: No. 4 to 1 in. nominal diameters. Various lengths.



Source: Parker-Kalon Div., General American Transportation Co., Clifton, N. J.



Yardley Type D Stud

Form: Threaded stud with knurled external surface. Designed to be molded into plastic, rubber, and ceramics.

Design Features: Provides a permanent threaded stud attachment for molding into suitable nonmetallic materials.

Materials: Aluminum and brass.

Sizes: No. 4-40 to ¼-28 external threads, Class 2.

Source: Yardley Precision Products Co., Yardley, Pa.

Zip-Grip

Form: Prevailing-torque type, self-locking headless set screw. Lock activating threads pull screw toward its head and produce an interference fit at the other threads on the screw to develop firm locking grip. All threads of screw must be fully engaged for proper locking action.

Design Features: Reusable. Can be used in standard Class 2 tapped hole. When removed, the screw resists only two turns, then performs as standard Class 2 fit. Particularly suited for adjusting or metering screw applications.

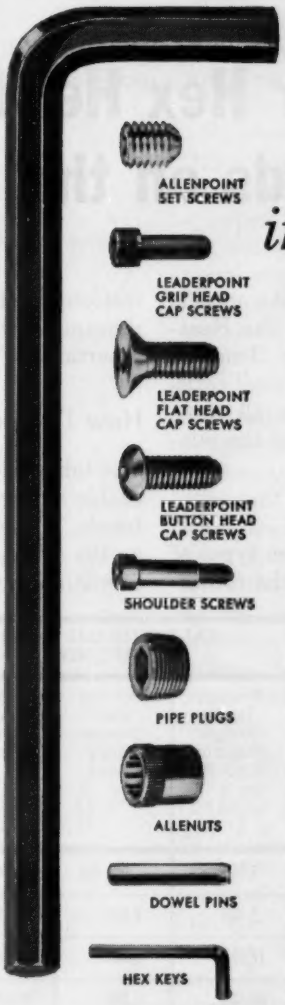
Materials: Steel, alloy steel, stainless steel, and brass.

Sizes: No. 4 to ¾ in. nominal diameters. Various lengths. Body style is hex socket or headless slotted. Point styles include cup, flat, oval, cone, and half and full dog.

Source: Set Screw & Mfg. Co., Bartlett, Ill.

(See Ad, Page 215)

Genuine ALLENS



...first choice of industrial designers for stronger, tighter fastenings!

Here's the way to figure it:

The cost of *genuine* Allen Hex Socket Screws is such a minor fraction of your assembly costs that you'll surely want *your* products to have the many advantages that only *genuine* Allens can give you!

1457 STANDARD ITEMS

ADVANCED DESIGN FEATURES: "Pressur-forming" that preserves the long fibers throughout the length of Allen Hex Socket Screws . . . the deep, full circle bite of Allenpoint Set Screws . . . deep, clean, strong-walled sockets . . . these, and many other advantages that make your product better, are yours *only* with *genuine* Allen Hex Socket Screws and related products.

WRITE FOR . . . Allen "Technical Library" handbooks filled with helpful socket screw data—answers to any questions you may have on specifications and dimensions—special alloys—finishes and surface treatments—strength characteristics, etc. Or ask your industrial distributor for copies.

50 ANNIVERSARY YEAR ALLEN HEAD 1910-1960

Genuine Allen products are sold only through leading Industrial Distributors. Your Industrial Distributor will give you practical advice on Allen products and he'll provide samples—and special help from Allen's Engineering Service.

THE ALLEN MANUFACTURING COMPANY, HARTFORD 1, CONNECTICUT

PLANT AT BLOOMFIELD, CONNECTICUT • WAREHOUSES IN CHICAGO AND LOS ANGELES

Circle F-58 on Page 97

FASTENOMICS

TIPS ON FASTENER APPLICATIONS BY **STANSCREW**

Socket Head or Hex Head Cap Screws? It All Depends on the Application

In selecting a Cap Screw, the conditions of a specific application may make the Socket Head, the Heat-Treated Hex Head, or the Bright Hex Head an obvious choice for greatest economy and most satisfactory performance. Stanscrew provides all three varieties, and we will attempt to point out the relative advantages of each.

Two Basic Differences

The essential differences between the three types of fasteners are their relative strengths and the conformations of the heads. In addition, the general appearance of the product will sometimes indicate using a particular fastener.

How Do Strengths Compare?

The table below gives the relative tensile, shear, and usable strength in tension of all three types of fasteners. The usable strength has been calculated based on the average pre-stressing of the fasteners to 80% of minimum yield strength.

SIZE	SOCKET HEAD CAP SCREWS			HEAT-TREATED (SAE Grade 5) HEX CAP SCREWS			BRIGHT HEX CAP SCREWS		
Diameter and Threads Per Inch	Minimum Tensile Strength (Based on 160,000 PSI)	Minimum Shear Strength (Single Shear)	*Usable Strength In Tension	Minimum Tensile Strength (Based on 120,000 PSI thru ¾" & 115,000 PSI for ⅞" & 1")	Minimum Shear Strength (Single Shear)	*Usable Strength In Tension	Minimum Tensile Strength (Based on 68,000 PSI)	Minimum Shear Strength (Single Shear)	*Usable Strength In Tension
¼-20	5,088 lbs.	2,544 lbs.	3,434 lbs.	3,816 lbs.	1,908 lbs.	2,442 lbs.	2,162 lbs.	1,081 lbs.	1,272 lbs.
⅜-16	12,400	6,200	8,370	9,300	4,650	5,952	5,270	2,635	3,100
½-13	22,704	11,352	15,325	17,028	8,514	10,898	9,649	4,824	5,676
¾-10	53,440	26,720	36,072	40,080	20,040	25,651	22,712	11,356	13,360
⅞-9	73,920	36,960	49,896	53,130	26,565	29,937	31,416	15,708	18,480
1-8	96,960	48,480	65,448	69,690	34,845	39,269	41,208	20,604	24,240

**Based on average pre-tensioning of the fastener to 80% of minimum yield strength*

Applications Pointers Based On Relative Strengths

By considering strength requirements, coupled with relative costs, the design engineer can often quickly determine the best fastener for a specific application.

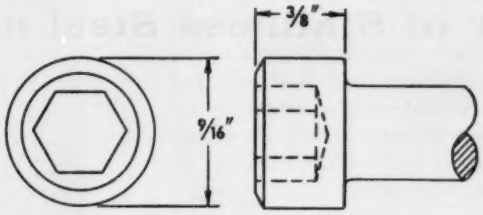
Here are some obvious examples:

1. When you need the greatest possible fastener strength in a limited joint area, socket cap screws are your obvious choice.
2. In rigid joints, heat-treated hex cap screws provide the greatest possible clamping force *per dollar cost.*
3. In bolting low strength materials, where high clamping forces cannot be applied without indentation, bright hex cap screws are the most economical selection.

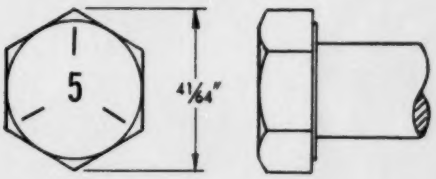
Additional information on the relative merits of heat-treated and bright hex cap screws is detailed in an earlier advertisement. (Copies forwarded promptly upon request.)

Difference In Head Size and Conformation

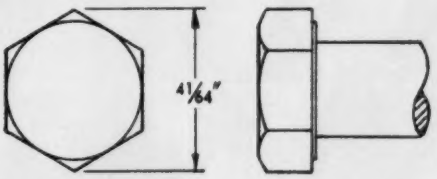
The drawings below show the relative dimensions and conformations of a typical socket and hex head cap screw (size used is 3/8" diameter.)



SOCKET HEAD CAP SCREW



HEAT-TREATED HEX CAP SCREW



BRIGHT HEX CAP SCREW

Application Pointers Based On Conformations

Again, the different head conformations dictate the use of a specific fastener for many applications. In crowded joints, smaller socket cap screws can often solve problems. They are obviously superior for flush mounting applications where counter-sinking is desired. In tight locations, they require far less wrench clearance.

Other wrenching factors also play an important part in determining whether socket or hex heads are best. If blind wrenching is indicated, socket heads are the outstanding choice. On the other hand, for consumer equipment, we can assume that conventional wrenches for hex head screws will be more commonly available than socket screw wrenches.

For industrial equipment, such as machine tools, this situation can be rectified by shipping the required socket wrenches (hex keys) directly with the product, attached to it in some simple fashion. Since hex keys are relatively inexpensive, compared with conventional wrenches, this enables the designer to provide customers with a more complete piece of equipment without appreciably raising the cost.

What About Appearance?

Although it is a somewhat intangible factor, a wise designer should consider the relative appearances of the two types of fasteners before arriving at his final selection. For example, in small-size precision equipment, socket head cap screws often contribute to a more finished, precision appearance. On the other hand, the use of only three or four fasteners to attach a large cover plate to a huge piece of equipment may present a somewhat incongruous appearance, even though they are adequate from the standpoint of tensile and other strengths. Here, a large number of less expensive fasteners may be more desirable.

Don't Create Inventory Problems

Overspecialization in selecting fasteners can defeat any economies realized, if it results in excessive inventories. Therefore, whenever possible, attempt to combine fasteners used for various applications. For example, good inventory practice usually indicates stocking only the strongest grade of any given fastener size and using it for all applications . . . except where extremely large quantities are involved.

For Further Information

Call your Stanscrew fastener specialist, for suggestions on your particular assembly problem. He is quickly available for consultation through your local Stanscrew distributor . . . who offers over 5,500 different standard fasteners . . . can supply an economical answer to almost every industrial fastening need.

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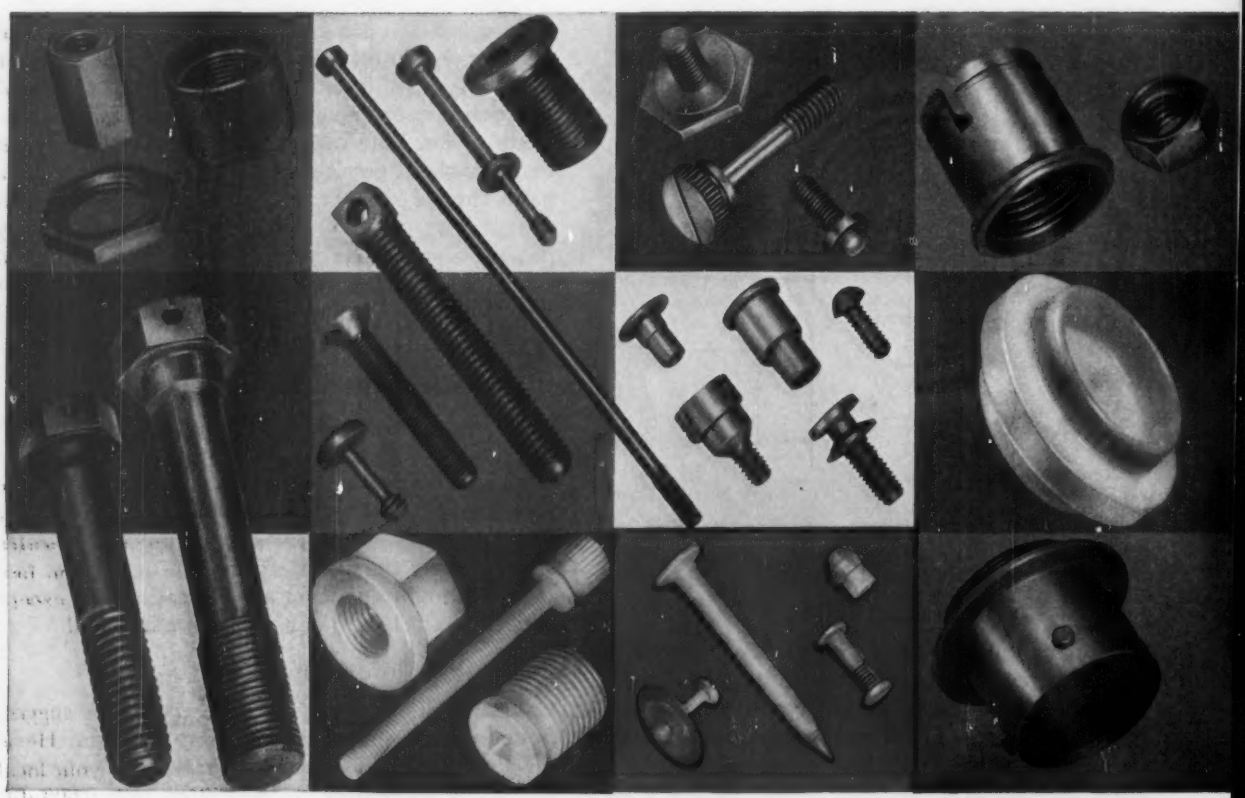

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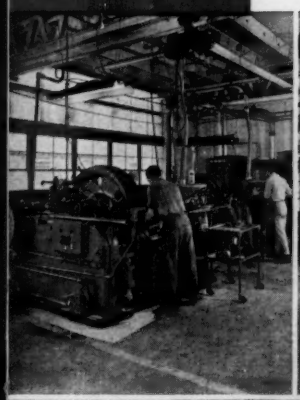
Million dollar inventory includes 12,000 different standard fasteners of Stainless Steel and Nylon. Special and standard machines of every kind assure immediate service on *special* fasteners.

High speed and precision equipment includes single and multiple spindle automatic screw machines, cold headers, hot forging and stamping equipment and machines for centerless grinding, threading, slotting, turning and tapping. Our raw material stock includes Stainless Steel in 30 different analyses while Nylon, Delrin, Teflon, P.V.C., Lexan, etc., are carried in 10 different formulations.

Our line of *nylo-fast*® Nylon fasteners, either standard or special specifications, is answering the needs for applications where Nylon properties are desirable. *Nylo-fast* fasteners can be made in any color, they are unaffected by commercial solvents, alcohols, gasoline, oils or even boiling 40% caustic soda. They withstand continued temperatures up to 250° F. They are light, elastic and resilient and resist high voltages at commercial frequencies.



Send us your drawings and specifications for quotations or engineering counsel. Our 33 years of engineering experience with problems of corrosion due to thermal, electrical or chemical action can be helpful to you. Or send for literature or specific information about Anti-Corrosive facilities, policies, inventory of standard items or specially fabricated fastenings.

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For operating dependability and efficiency, we might suggest a slight modification of design or material of the part in use. Then again, one of our many standards may better suit your needs. Either way, if you have a particular connection problem—one requiring a low-cost solution, let us see what we can do to help. The services of our specialists are readily available through your Screw and Bolt representative. Contact him today or write us direct. Others do.

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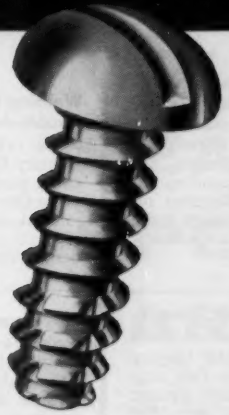
AMERICA'S MOST COMPLETE LINE OF INDUSTRIAL FASTENERS

Got a problem that calls for thread-cutting screws?

PARKER-KALON offers three new, improved thread-cutting screws for every application in every material

1 New, Improved P-K Type F*

. . . hardened thread-cutting screws developed for use in friable, granular or brittle material. The pilot, with its five tapping flutes, cuts a machine screw thread as the screw is turned in. The Type F is ideal for making fastenings to ferrous and non-ferrous castings, bronze or brass forgings, heavy gage sheet metals, structural steels, plastics and resin-impregnated plywood.



2 "Pentap"... the new, Improved P-K Type B-F*

(formerly F-Z) combining the five thread-cutting flutes of the Type F screw with the coarse-pitch, widely-spaced threads of the P-K Type B. The thread-cutting "Pentap" Type B-F distributes cutting pressure evenly, lets chips drop to the bottom of the hole, and prevents cracking of material. It is designed for making fastenings to comparatively thin sections and bosses in friable and brittle plastics.

3 P-K® Type L†

. . . is a completely new and improved thread-cutting screw developed by Parker-Kalon especially for use in Nylon. The Type L functions as a combination thread-cutting and thread-forming screw in that it cuts a small amount of the Nylon to allow the full diameter threads to form. Type L offers a particular advantage in Nylon assemblies which must be disassembled for service, because *the P-K Type L can be removed and replaced without stripping or galling.*

The five cutting flutes on the new, improved P-K Type "F" and "BF" reduce pressure development by 80 percent! The completely formed threads on these screws have sharper cutting edges, and 5 deep flutes that are of continuous depth. These features make for better clearance of the accumulated material and assure minimum stresses in driving, and avoid the possibility of stripping or galling.

FOR SEMS . . . and Neoprene or Nylon washer **STAPS*** in thread-cutting and thread-forming tapping screws, or machine screws in any kind of pre-assembled fastener-washer combination, P-K can supply them, too!

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*Patent Pending †U. S. Patent 2,350,346

FOR SAMPLES OF P-K THREAD-CUTTING SCREWS AND SEMS, CALL YOUR LOCAL P-K "BULK-STOCKING" DISTRIBUTOR

PARKER-KALON®
fasteners

PARKER-KALON DIVISION, General American Transportation Corporation, Clifton, New Jersey • Offices and Warehouses in Chicago and Los Angeles

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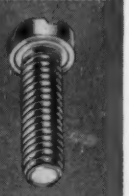
Get more dependable holding power for better product assembly with these National SPECIALTY FASTENERS!

Lok-Thred® Bolts, Studs, Screws—Seal and lock against involuntary loosening... Lok-Thred re-forms the metal of the receiving thread under high compressive stresses into intimate contact with itself, eliminating all voids. Yet, it's fully re-usable. Requires no selective fits. Can be used with ordinary tools. Available in all sizes of bolts, studs, screws... No. 6 or larger.

Welding Fasteners and Weldnuts—Provide trouble-free assembly of fabricated metal parts... Use National welding fasteners when primary fasteners must be cleanly welded into exact position. National's complete line of projection welding screws and nuts is available in stock sizes, for optimum welds in materials .030 to ¼" thick. We will develop special designs for you.

Spin-Lock® Fasteners—Give you strength at low cost, with self-locking, ratchet-tooth action... Spin-Lock machine and tapping screws have angled teeth to permit fast, easy tightening. They require about 20% greater torque to loosen. Available in pan, truss, flat and hex heads; slotted or Phillips recessed heads; No. 4 to ⅜" diameters, lengths from twice diameter and up.

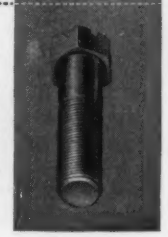


Flex-Head® Locking Screws—Self-locking, highly resistant to fatigue, shock, impact... Tight locking results from flexing of the head and axial spring tension produced when fully torqued against a rigid seat. Flex-Head screws are identical in dimension, and interchangeable with standard machine screws. Made of 1022 steel and heat-treated for top strength.

Thread Cutting Screws—For joining metals or plastics without tapping... Use wherever it is desirable to remove rather than displace thread material. Four types: 1, 23, 25, and F cover most applications. Phillips or slotted heads, all styles, all sizes. Also type A and B tapping screws for fastening light sheet steel or light gauges of other metals.

Tuff-Tite® Cushioned Fasteners—Seal openings, eliminate vibration noises, absorb shock... Pre-assembled neoprene washers also prevent finish marring! Available as tapping screws, thread cutting screws, machine screws, roofing bolts, stove bolts, or wood screws; with Phillips or slotted heads; pan, round, truss or hex head styles.

Lock Nuts—Three types, to meet every requirement... 1. *Huglock*, for locking without seating and under adverse conditions. 2. *Marsden*, free-running until seated... for minimum-cost locking. 3. *Drake*, a two-piece design for use under severe stresses, shock, vibration. All types are all-metal, fully re-usable without loss of positive locking action.



Place® Bolts—Self-locking...resist impact, shock and fatigue failure by controlled spring action of reinforced, diaphragm head... Place bolts resist involuntary loosening when rigidly seated. Typical uses: connecting rod bolts, main bearing cap screws, flywheel bolts. Available in high carbon or alloy steel, in a wide range of sizes.

Save yourself time and trouble in searching for the right fastener. Make National your *one source* for standards, specialties and special designs. Our standard line includes all types and sizes... nuts, cap and set screws, machine bolts, carriage, step and elevator bolts, plow bolts; Phillips recessed head, or slotted, Sems, machine screws, wood screws; stove bolts, pipe plugs, cotter pins and rivets.

National can supply any nonstandard fastener, or design and produce specials for you. Write for National's *Special Products* booklet, or for information on the fastening specialty that interests you.

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Fasteners **Hodell Chains** **Chester Hoists**

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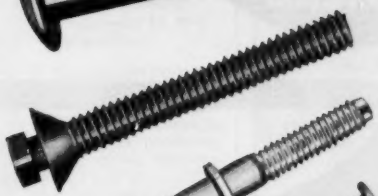
COLD-HEADED SPECIAL PARTS



Substantial savings are often achieved through the use of low-cost cold-headed parts in place of complex assemblies or pieces requiring several machining operations. The examples shown here represent a wide variety of possibilities, yet these are only a few of the thousands we have produced. Our sales engineers and field representatives are ready to give you skilled advice on potential adaptations to *your products. Just call your Elco man.*

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Circle F-65 on Page 97

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Southern Screw Company is a fastener specialist—makes nothing but threaded fasteners. Our long experience in the manufacture of screws, plus our advanced technology which includes rigid quality controls, is responsible for the production of the finest standard fasteners available anywhere.

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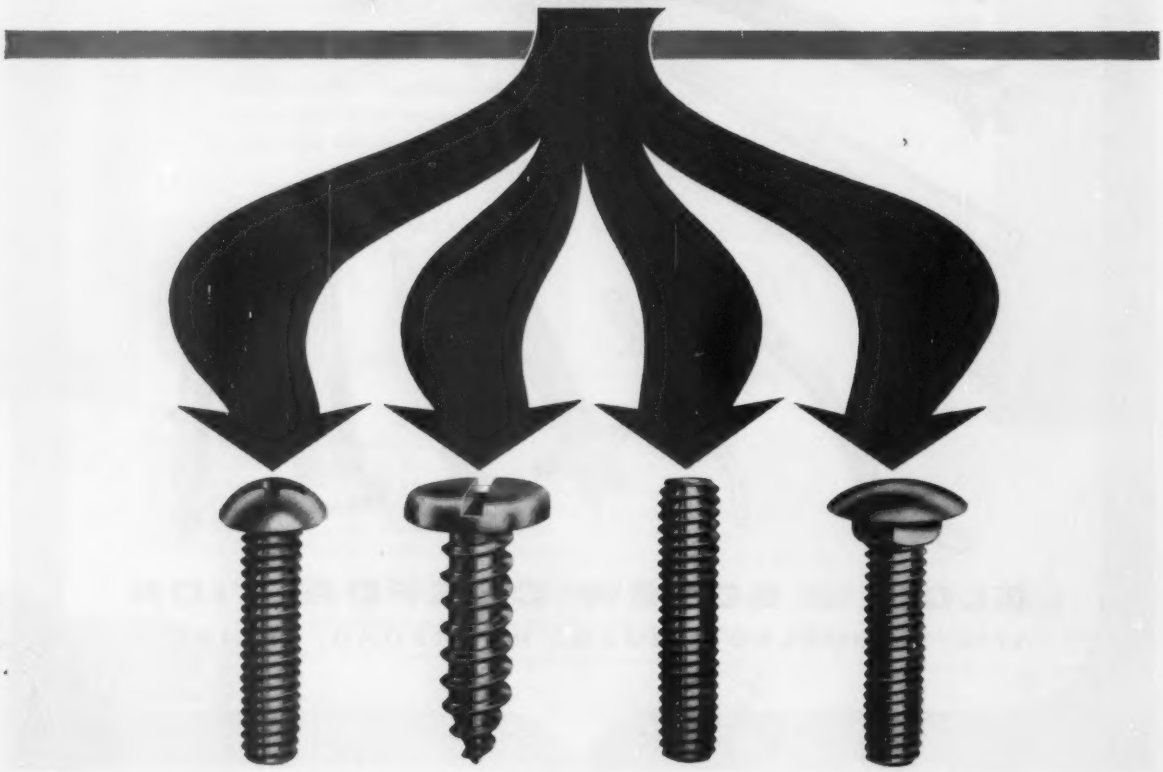

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42% sharper angle on point cuts deep into the metal in a circular manner!

An independent manufacturer tested all types of points to find the one that would hold best . . . and perform most dependably. He chose NU-CUP. Could you use this idea? Check No. 1. (Name of Mfr. on request.)

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Costs less than comparable hexagon head set screws.

If you are having trouble with stripped heads or insufficient holding power, chances are the Setko Slabbed Head Set Screws are just the idea you need . . . Available in all points and metals. Check No. 2!

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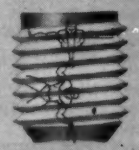

Slight variation of thread causes locking action on mating surface!

Proven as an outstanding principle in many products, Zip-Grip has found particular acceptance wherever the stress of movement or vibration occur. Makes an outstanding adjusting screw . . . Can be reapplied many times . . . Got an idea? Check No. 3.

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IDEA #4 TINY SCREWS DO BIG HOLDING JOB . . . THEY'RE CALLED "MINI-MITE"

You'll find them perfectly-produced counterparts to their big brothers!

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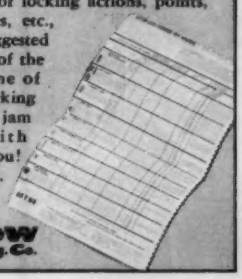
Helps you determine available combinations best for your particular application!

Here is another Setko first . . . A complete listing of locking actions, points, metals, drives, etc., including suggested applications of the complete line of Setko self-locking screws . . . It's jam packed with ideas for you! Check No. 5.



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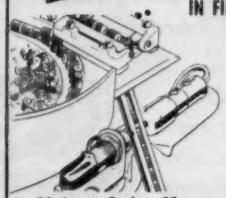
IDEA #6 "SETKO HOPPER FEEDER SAVED US $42,000 IN FIRST YEAR."



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Unique Setko Hopper Feeder design orients headless Set Screws then feeds them to a driving device . . . Savings like the one shown above are but one of the advantages (name of mfr. on request) . . . Product quality is consistent, etc. This cost-cutting idea is one you can't miss! Check No. 6.

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IDEA #7 NOW YOU CAN GET COLD FORGED "PERFECT HOLE" CAP SCREWS IN THE NEW '60 SERIES . . . *and in STAINLESS STEEL, TOO!*

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IDEA #8 THERE'S A BARREL-FULL OF IDEAS IN THE NEW 28-PAGE SETKO CATALOG #23.

The complete line of cost-cutting SETKO Socket Screw Products is at your fingertips.

You'll want this compact catalog for your personal use . . . And you'll particularly like the easy to read manner in which it has been prepared. Want a copy? Check No. 8.

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Please send me Idea information on items checked below. (If FREE samples are wanted of any of these products, send your specifications).

- ☐ 1. Nu-Cup
- ☐ 2. Slabbed Head
- ☐ 3. Zip-Grip
- ☐ 4. Mini-Mite
- ☐ 5. Self-Locking Selector Chart
- ☐ 6. Hopper Feeder
- ☐ 7. Cap Screw
- ☐ 8. Catalog

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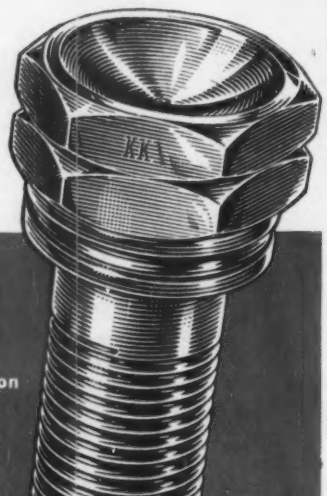
Klincher SELF-LOCKING Kapscrews

...available in various metals or materials to meet the most rigid specifications.

Klincher Self-Locking Kapscrews lock after the proper torque has been applied. The washer compresses causing the inside section of the washer to press against the shank of the bolt and kap shoulder locking-in radially and axially.

Klincher Self-Locking Kapscrews are particularly unequalled where vibration, tensile strength, corrosion and high temperature are factors. They will withstand temperatures up to 1600° Fahrenheit without seizure.

They are available in various metals or materials to meet the most exacting specifications and environment.



Write for more complete information on KLINCHER SELF-LOCKING KAPSCREWS

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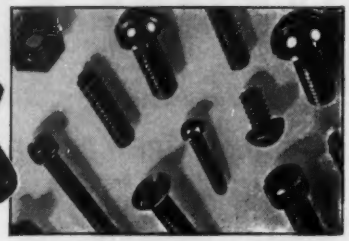

Molded Nylon **SCREWS** *and* **NUTS**

- *FASTEN and INSULATE WITHOUT BUSHINGS*
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Round, flat, and fillister head screws . . . slotted headless set screws. Hex and slotted cap nuts. Thread sizes 2-56 to ¼-20.

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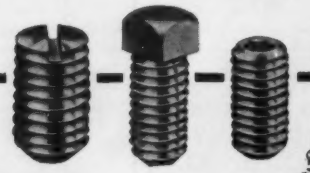
exactly right for any job . . . and you can get them FAST



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Uniform high quality — modern equipment and methods and rigid quality control guarantee precision quality.

Advice of specialists — expert engineering assistance, backed by 80 years of experience, is available to help solve problems.

Moore set screws simplify design, purchasing, production. Send for price catalog.

MOORE SET SCREWS

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Circle F-76 on Page 97

R B&W 116th year FASTENERS THAT SOLVE SPECIAL PROBLEMS

TENSILOCK® SCREWS AND NUTS

"Tensilock," the high tension locking fastener, bites with hardened ratchet teeth . . . holds tight. High residual tension, tooth grip, and spring action of flexible flange make required loosening torque as much as 40% more than tightening torque. ®TM

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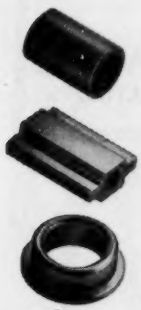


A variety of small parts is presently being produced by RB&W from powdered brass and stainless steel. Facilities can handle a wide variety of other small shapes, including nuts, gears, bushings, spacers, levers, cams, etc. Such sintered parts offer substantial production savings. Contact us with your requirements.

STAKED LOCK NUTS

Staked on opposite sides for positive grip and spring tension locking effect. Available in regular double chamfered style or acorn style (illustrated), in aluminum, steel, silicon bronze.

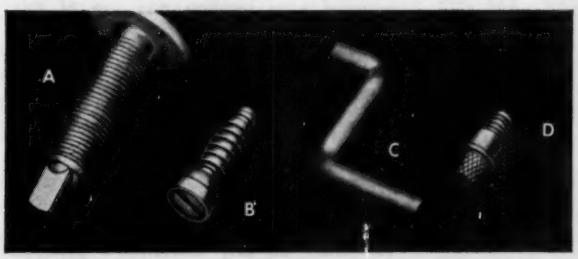
WELDING FASTENERS

RB&W standard welding screws have welding projections on top or bottom of head. Sizes from No. 6 through ½ inch. Welding Nuts can also be supplied.

Cold heading creates quality parts the low cost way

METAL FORCED to cold flow into shape results not only in savings but also in stronger parts. With uncut flow lines, the piece is better able to withstand stress concentrations.

No value analysis of product components is really complete without exploring what cold heading machines can do. Some examples:



ELIMINATE EXTRA OPERATIONS. Leveling screw (A), formerly made by riveting flat disc to set screw, now emerges as a stronger, single piece from a cold header.

ONE PIECE BETTER THAN TWO. Cold headed hose clamp screw (B) has integral flange which, after head is slotted, is forced up to form screwdriver shield. Before, piece was in two parts . . . with screw made on screw machine, and the shield a stamping fitted around head in extra assembly operation.

FASTER THAN FORGING. Shifter lever (C) is bent into double "L" automatically in bolt header . . . replacing 2-stage forging operation. The header does it at high speed from continuous rod.

METAL FLOWS TO SHAPE—NO WASTE. No longer cut on screw machine, insert screw (D) for plastic parts cost 40% less. Cold header uses just the amount of metal required. The threading and knurling, too, are done automatically at high speed.

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

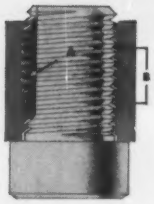
RB&W fasteners—Strong Point of any assembly

See our catalog in Sweets Product Design File

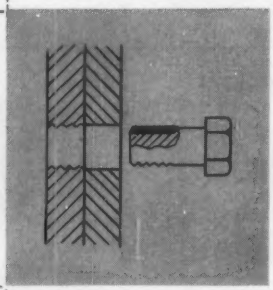
Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. **Additional sales offices at:** Ardmore (Phila.) Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

This is a LONG-LOK Self-Locking Screw. It is a one-piece reusable fastener, heat, vibration, impact and shock resistant.

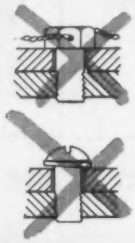
It is vibration resistant because the resilient, reformable insert (A) acts as a wedge between the male and female threads, causing a metal-to-metal drag (B).



LONG-LOK Self-Locking Screws are flush protruded and pass through normal clearance holes with finger pressure. No special clearance holes are required.



LONG-LOK Self-Locking Screws save time and money because they eliminate safety wire (and head drilling), and lock washers. They also save weight.



LONG-LOK Self-Locking Screws are available for aircraft, missile and commercial applications. They meet MIL-F-18240 Specifications and can be head marked for self-lock identification.

Write for Catalog LL-80

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Circle F-79 on Page 97

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MACHINE DESIGN

A PENTON PUBLICATION

CLEVELAND 13, OHIO

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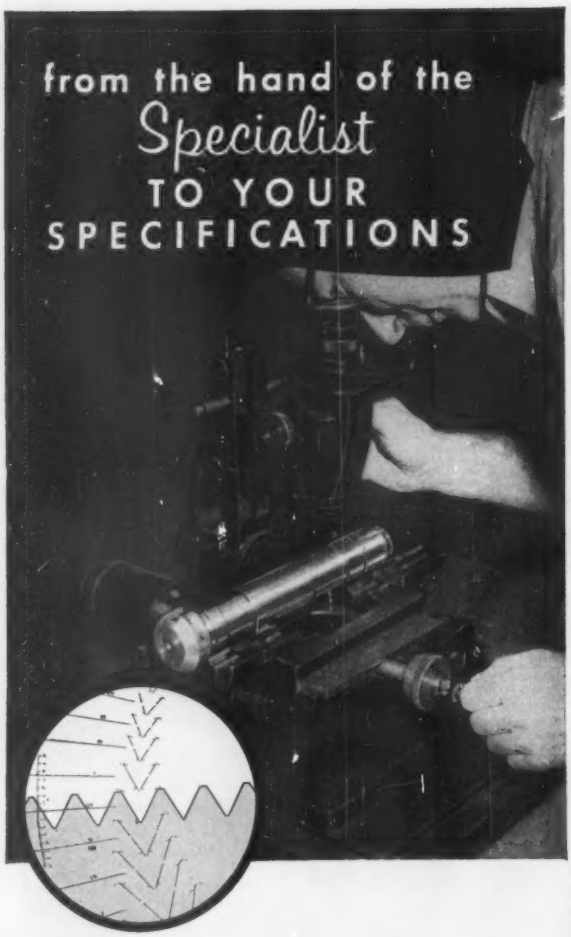

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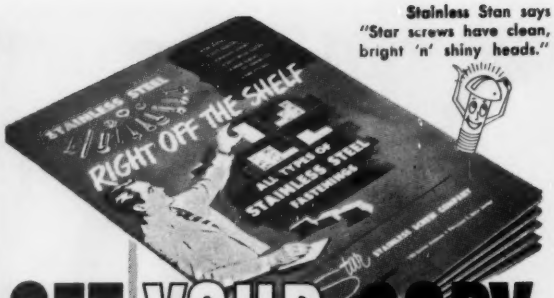

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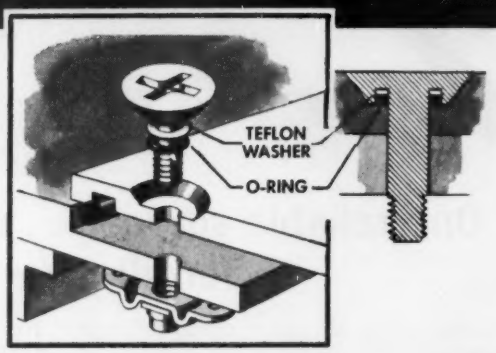

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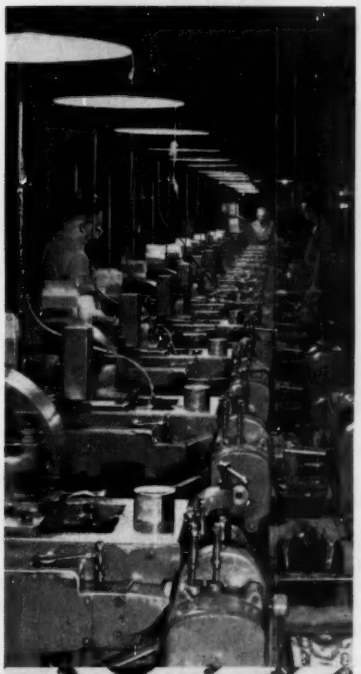

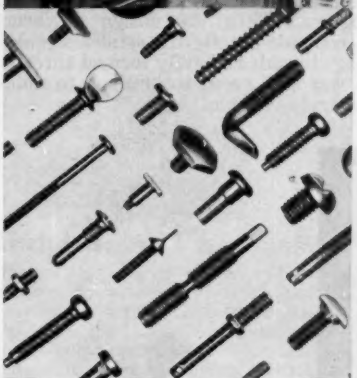

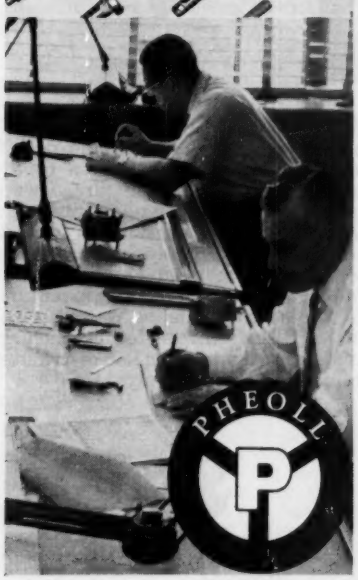

THE FACILITIES

Heading Department
Facility to head .040 to ⅝" in diameter wire covering a wide range of eccentric shapes of head, shoulders, etc., using cold, warm, and hot heading equipment.

Slotting Department
Facility to slot any, and all, head styles, end slotting, slabbing and milling.

Rolling Department
Thread rolling of machine screw, tapping screw, and fetter threads, spiral drive screws, knurling, plus various shapes and concentric grooves.

Shaving and Machining Department
Ability to point, groove, reduce, shave, drill, ream, skive and cut threads. Ability to shave the heads, or shank, top or bottom, allowing complete flexibility for all secondary operations.

Trimming Department
Trim and/or extrude various head styles, or blanks—notching and coining.

Washer Assembly Department
The ability to pre-assemble washer—double or single—out of any material including neoprene, plastic, fibers, or metal types to threaded part. 35 pieces of equipment assure complete flexibility and dependable service.

Drilling Department
The ability to drill and tap any product where the hole is parallel to the shank, plus cross drilling of fillister heads, etc.

Shank Slotting
Produces Thread Cutting Screws of finest quality.

Pinch-Pointing Department
Ability to produce a sharp point for any product.

Punch Press Department
Ability to perform stamping, flattening, bending, piercing, staking operations of all types.

Plating Department
Cadmium and zinc plating is performed daily. Rust proof operations and lubricants and waxes are applied routinely. Passivation of stainless steel and of working brass and copper for special plating requirements are part of job.

Custom Department
The ability to handle long and unusual lengths of wire, plus the minimum quantities needed for samples, or pilot model runs.

Washing Department
All parts are washed by alkaline cleaning units after every operation. Ball burnishing for stainless steels, and roto-finishing for brightening and burr removal are standard operations in this department.

Heat Treating Department
Consists of the most modern and complete up-to-date facilities in the industry.

Tool and Die Division
Header tooling, various types of turning tooling, and a variety of machine tooling in heat treated, or non-heat treated condition provides a source of service when needed.

Chemical Laboratory
Checks work in process for heat treating and plating.

Machine Design and Repair Department
Pheoll's unique engineering and technical know-how allows for unusual and efficient building of time saving equipment.

Metallurgical Laboratory
Physical testing analysis for hardness, tensile, torque, and grain structure by use of photographs and testing equipment —plus carbon determination on raw material, or finished goods.

THE FASTENERS

STANDARDS

Slotted—Phillips Machine Screws
Machine Screw Nuts
Slotted—Phillips Tapping Screws
Slotted—Phillips Wood Screws
Stove Bolts
Set Screws
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SPECIAL SCREWS AND BOLTS

Many user advantages result from Pheoll's method of cold working and thread forming these parts. They can be made from steel, brass, copper or alloys. Specialty items of this type are manufactured to order. Full information will be supplied upon request.

THE FUTURE

Pheoll is sharing importantly in these accelerating fastener needs as demonstrated by these typical contributions: "Schweppe Studs", "Lev-L-Screws", "Fin-I-Shield" Screws," Crating Bolts" and "Sprews". Many more forward-looking developments are under way. You can be sure that when fasteners are **(1)** manufactured for less cost; **(2)** simplified in design; **(3)** improved structurally—Pheoll will be first to do it!

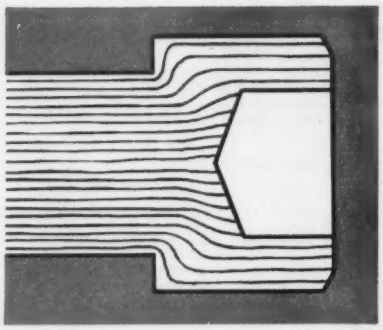
Pheoll finds it an exciting challenge to be part of the Industrial world at a time when far-reaching scientific, electronic and engineering advancements are creating new fastener demands, new fastener problems.

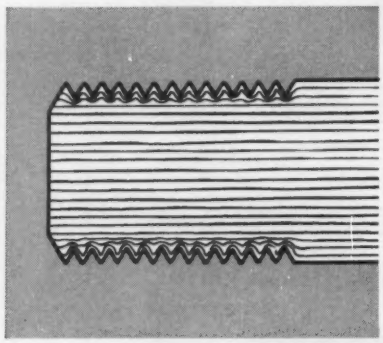
PHEOLL MANUFACTURING CO., INC.
5700 West Roosevelt Road Chicago 50, Illinois

Circle F-71 on Page 97

How imaginative design produced a better socket head cap screw

Forged heads:
It used to be that all socket head cap screws were *machined* from bar stock, but research revealed that fatigue failures were most likely to occur where the natural lines of strength in the metal were cut. So SPS began forging the heads of UNBRAKO cap screws . . . thus maintaining good flow lines and increasing fatigue strength.



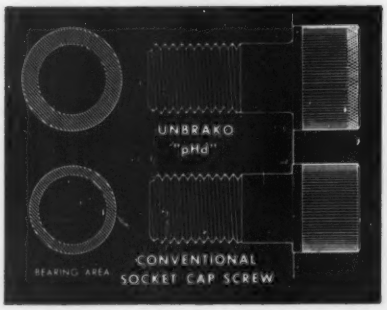


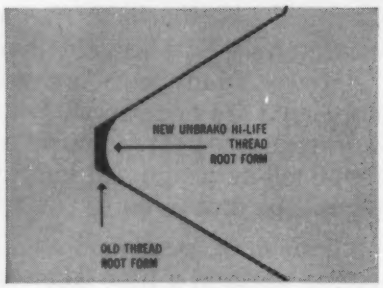
Fully formed threads:
A similar problem in the threads was solved in a similar way. The threads—even more fatigue prone than the head—had always been cut or ground. But now threads were pressed in by precision dies. Once again, maintaining the flow lines of the metal added greatly to the screw's strength.

So fasteners were now precision fabricated throughout. Then the design engineers took over, for despite the strides signaled by forged heads and fully formed threads, there was still much to be done to make screws truly reliable.

pHd* heads:
Research indicated that there simply was not enough load bearing area under the head. What came out of this finding? UNBRAKO pHd cap screw, with a larger head diameter that increased load carrying capacity as much as 2⅓ times, allowing fewer screws per assembly.

** pHd stands for "proper head design"*





Hi-Life thread:
Then, as you might expect, the design engineers turned their attention to the threads. In the root of the thread were sharp corners where fatigue failure could begin. At the SPS Laboratories for Advanced Research, photoelastic studies made strikingly evident the value of a *smoothly radiused* root over a conventional flat thread root. And so was born the UNBRAKO Hi-Life thread form, which reduces stress to a minimum and distributes the remaining stress evenly.

Now you have at your disposal a socket screw that is stronger in the head, stronger in the thread. The UNBRAKO pHd with Hi-Life threads is indeed the advanced fastener for the '60's. All this—at no additional cost. Standard Pressed Steel Co. INDUSTRIAL FASTENER Division, SPS, Jenkintown 18, Pa.

SPS

where reliability replaces probability

Circle F-70 on Page 97

CHAPTER

28 Washers

SIMPLE but important elements of fastener hardware, washers can serve several different purposes. Primary functions are as a bearing surface, a spring-takeup device, or locking element. They can also be used to improve appearance, to provide sealing, or to prevent damage to finished surfaces. Washers discussed in this section are typical of basic types designed specifically for use in fastener assemblies. In addition to these, a wide range of special-purpose and custom made types are available from different manufacturers.

Barclad Washer

Form: Single-unit washer with compressible, flowable-type insert enclosed in a metal retainer to fit bolts or screws. Tightening the fastener forces the sealing or cushioning material downward into the fastened member, and into the clearance hole between the fastener and fastened member.

Design Features: Suitable for light, medium, and high-torque requirements. Provides effective seal against air, liquids, or gases at low and high pressures. Application temperature range is −100 to 1200 F. Can be used as cushioning washer to prevent cracking or chipping of porcelain or enameled surfaces.

Materials: All standard metals and synthetic or natural sealing and cushioning materials.

Sizes: All standard headed fastener diameters. Styles include permanent and reusable types.

Source: L. J. Barwood Mfg. Co. Inc., Everett, Mass.

Bartite Sealing Washer

Form: One-piece washer unit consisting of dome-shaped metal retainer into which sealing compound is bonded. Tightening the fastener forces the sealant into cavities between clearance hole and fastener thread, fastened material and washer, and fastener head and washer hole.

Design Features: Sealing compound is stable, nonaging, and withstands temperatures from −100 to 300 F without change. Provides effective seal against water, oils, greases, acids, alkalies, salts, alcohols, hydrocarbons, and ozone.

Materials: Retainer is mild, high-carbon, heat-treated, or stainless steel. Sealing compound is of polyvinyl chloride base.

Sizes: Standard screw and bolt sizes up to ⅝-in. diameter.

Source: Bartite Products Corp., subsidiary of L. J. Barwood Mfg. Co. Inc., Everett, Mass.

Compression (Belleville) Washer

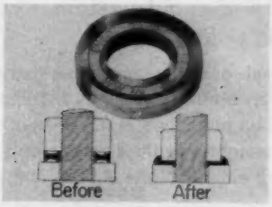
Form: One-piece, all-metal, conical-disc washer. Locking action is obtained through the washer compression as the nut or bolt is tightened.

Design Features: Reusable. Designed to be used under static loads. Washers maintain a higher bolt or stud load than conventional washers.

Materials: All standard engineering materials.

Sizes: ¼ to 1⅛-in. bolt sizes.

Source: Produced by several manufacturers. Photo, courtesy Solon Mfg. Co., Solon, Ohio.



Dubo-Ring

Form: One-piece nylon lockwasher with a double V shape. When nut is tightened against washer, ID of the washer grips into threads of the bolt and nut, and flows into the opening of clearance hole. Simultaneously, the OD flows over the outer edges of the nut, locking and sealing it.

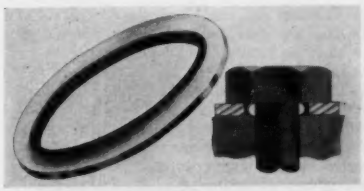
Design Features: Reusable. Provides self-sealing and self-locking action. Will not gall or seize mating threads. Vibration and shock do not affect the positive double-locking action. Washer is stable to 400 F. Tensile strength is 10,000 psi.

Materials: Nylon 6.

Sizes: 1/8 to 1 1/2-in. nominal bolt diameters.

Source: Nylogrip Products, Watertown, Mass.

(See Ad, Page 226)



Dyna-Seal

Form: One-piece washer unit consisting of an inner flared rubber seal ring bonded to an outer confining steel washer. Projecting portion of rubber seal is compressed when fastened, causing inner flared edge to form a convex sealing surface opposing internal fluid pressure forces.

Design Features: Reusable. Provides a leakproof seal against gases and fluids under bolt heads, rivets, flanges and fittings. Sealing action is assisted by pressure forces. Resilient rubber ring provides a lockwasher action that resists vibration. Can withstand steady or pulsating pressures up to 10,000 psi without losing effectiveness of seal. One-piece washer design simplifies mounting problems and facilitates assembly operations. Temperature service range is 250 to −65 F. Gives maximum bearing surface under head of bolt or rivet.

Materials: Washer is steel; inner seal ring is oil-resistant synthetic rubber compound.

Sizes: 0.125 to 1.250-in. maximum bolt OD. Washer OD from 0.315 to 2.016 in.; thickness from 0.041 to 0.134-in.

Source: Precision Rubber Products Corp., Dayton, Ohio.

Everlock Lock Washers

Form: Type B American Standard tooth lock washers. Under pressure of application, multiple heat-treated teeth on outer

How SHAKEPROOF Protects Your Product's Reputation

Here is the answer to one of industry's toughest problems . . . how to reduce costly inspection rejects and avoid customer complaints due to fastening failure.

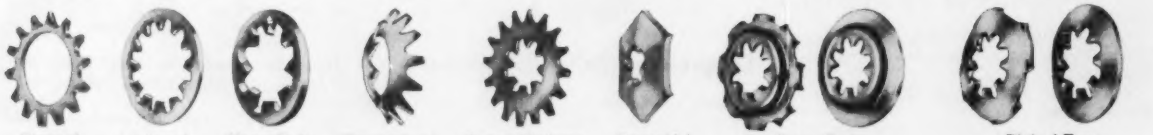
Shakeproof engineers have gathered formidable evidence that only one washer locks . . . where others fail! Their findings, just published in the booklet offered at the right, prove that "weight and thickness" don't lock a fastener, and that "spring action" alone isn't locking action.

They have conducted tests with various types of washers commonly used for protection against failure caused by handling and operational vibration. Results show that only Shakeproof Lock Washers retained 100% relative locking efficiency.

Be sure to protect your product's performance and reputation with the one top-quality, top-performance lock washer . . . Specify SHAKEPROOF . . . the *original* toothed lock washer!

Send for this Free Booklet Today—it is filled with factual test data and actual case histories which show how you can be sure of quality at every step in the assembly of your product.

STANDARD SHAKEPROOF LOCK WASHERS INCLUDE:



External Type · Internal Type · Heavy Duty Internal Type · Countersunk Type · External-Internal Type · Pyramidal Type · Dome Type Toothed or Plain Periphery · Dished Type Toothed or Plain Periphery

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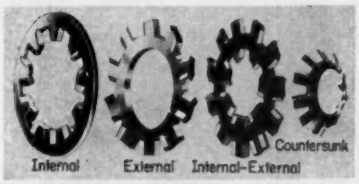
LOOK TO SHAKEPROOF—THE LEADER IN FASTENING



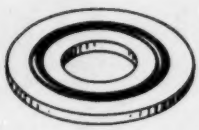
or inner, or both, diameters of washer bite into fastener and working member to provide locking action.

Design Features: Each tooth is formed to provide two chisel edges, projecting on opposite faces. Sufficient spring action exists in tooth construction to accommodate fastener expansion and contraction under severe temperature changes. Several types have been standardized. Internal type is used under small head screws (fillister, etc.) or where it is desirable to hide teeth for appearance or to prevent snagging. Heavy internal type is used with heavy bolts and nuts, and with heat-treated bolts, usually on castings and heavy machinery or equipment. External type is used with fasteners having heads large enough to contact the lock washer teeth (round, pan, binding head, etc.). Countersunk external type is used with flat or oval-head countersunk screws. Internal-external type is used where large bearing surface is required, for oversize or elongated holes, and as an insert between adjustable members to maintain adjustment settings.

Materials: Hardened and tempered medium-carbon steel, 410 stainless steel, or bronze.

Sizes: No. 2 to 1¼-in. nominal screw sizes. Size range varies for individual types.

Source: Thompson-Bremer & Co., Div. of American Machine & Foundry Co., Chicago, Ill. Basic washer details given in *American Standard Lock Washers*—ASA B27.1-1958.



Gask-O-Seal

Form: One-piece washer unit consisting of cup-shaped metal retainer into which rubber seal is bonded. Projecting portions of rubber seal are pressed flat when fastened, providing contact with all internal surfaces.

Design Features: Dimensions of metal member are such that rubber sealing element is completely confined; no cold flow is developed. Positive contact of seal on all four sides produces effective sealing action at high and low pressures. Metal-to-metal contact of parts is maintained for high strength. Simple design of seal eliminates need for close tolerances. Washer is reusable. Used primarily to seal rivets and bolts in joints with close-fitting holes.

Materials: Metal retainer is chrome-moly steel; seal is silicone rubber or black nitrile rubber in one of several compositions.

Sizes: 3/16 to 5/16-in. nominal ID.

Source: Parker Seal Co., Culver City, Calif.

Helical Spring Lock Washers

Form: Helically coiled hardened wire washer. It usually has slightly trapezoidal section, thicker at ID than OD. Washers are coiled so that the free height is approximately twice the thickness of the washer section.

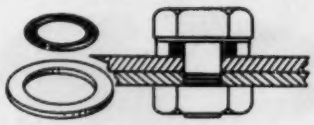
Design Features: Functions as spring takeup device to compensate for developed looseness and loss of tension between component parts of an assembly, and as a hardened thrust bearing to facilitate assembly and disassembly of bolted fastenings by decreasing the frictional resistance between the bolted surface and the bearing face of the bolt head or nut.

Materials: Carbon steel, corrosion-resistant steel, aluminum-zinc alloy, phosphor-bronze, silicon-bronze, or K-Monel.

Sizes: No. 2 to 3 in. nominal sizes. Washer styles include light, medium, heavy, and extra heavy types as well as different coil shapes. Size range varies for individual styles.

Source: *American Standard Lock Washers*—ASA B27.1-1958. Photo, courtesy Reliance Div., Eaton Mfg. Co., Massillon, Ohio.

(See Ads, Pages 227, 228, 229)



Lock-O-Seal

Form: Two-piece washer assembly consisting of synthetic rubber O-ring mounted inside metal support ring.

Design Features: Dimensions of support ring are such that rubber sealing element is completely confined; no cold flow is developed. Positive contact of seal on four sides produces effective sealing action at high and low pressures. Metal-to-metal contact of parts is maintained for high strength. Simple construction of seal eliminates need for close tolerances. Washer is reusable. Not recommended for use with coarse or large threads. Used for liquid and gas sealing of bolted and riveted joints.

Materials: Support ring is steel, aluminum, stainless steel, or chrome-moly steel; O-ring is Kel-F plastic, white or red silicone rubber, or one of several compositions of black nitrile rubber.

Sizes: No. 2 to 2 in. nominal ID.

Source: Parker Seal Co., Culver City, Calif.

Nyltite Headed Sleeve

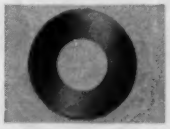
Form: Nylon headed sleeve which is slipped over bolt or into hole. As the nut is drawn up, sleeve is compressed and cold flows to new shape to form washer surfaces at both ends.

Design Features: Compression of bolt and nut goes beyond plastic memory of sleeve, and only a slight tendency to resume former shape is retained. This slight tendency is enough to insure locking action. Fills all threads and irregularities between bolt and hole. Insulates against corrosion, dampens vibration, and provides a seal that will withstand temperatures up to 250 F.

Material: Nylon.

Sizes: 0.073 to 1 in. nominal screw diameters. Various grip lengths. Styles include rolled head with and without sleeve.

Source: Nyltite Corp. of America, Newark, N. J.



Plain Washers

Form: Standard flat disc washers with center opening to fit under nut or head of bolt or screw. Washers are standardized in Types A and B. Type A has broader tolerances than Type B which is manufactured in narrow, regular, and wide series.

Design Features: Used to insulate exposed nut or bolt head from the part, to improve appearance, to protect part surface from damage, or to distribute load over wider area of the contact surface. Type A washers are recommended for general purpose applications where washer tolerance and workmanship are not important. Type B washers are recommended where higher quality of workmanship and greater dimensional accuracy are required.

Materials: All standard engineering materials.

Sizes: Type A; 5/64 to 3½ in. ID, 3/16 to 5½ in. OD; 0.020 to 0.284 in. thickness. Type B; 0.068 to 3½ in. ID, ⅛ to 7 in. OD, 0.025 to 0.375 in. thickness. OD and thickness of Type B washers vary for individual series.

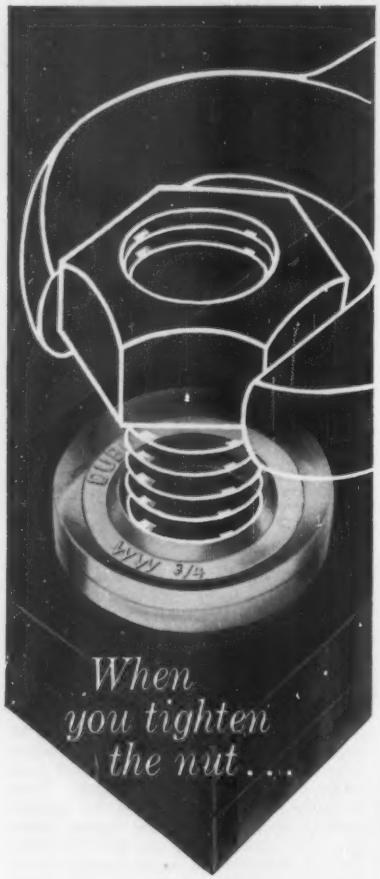
Source: *American Standard Plain Washers*—ASA B27.2-1958. Photo, courtesy Shakeproof Div. of Illinois Tool Works, Elgin, Ill.

Preload Indicating Washer

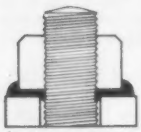
Form: Four-piece washer assembly consisting of two concentric steel rings sandwiched between two close-tolerance, hardened steel washers. Inner ring is thicker than outer ring by predetermined amount. Tightening of bolt compresses inner ring. When outer ring can no longer be moved freely by pin inserted in peripheral hole, known preload in bolt is indicated.

Design Features: Indicates an average preload of 80 per cent of minimum bolt yield strength. Accuracy is within 10 per cent. Presence of sealant, oil, grease, and

This new lock and seal washer is just plain **REVOLUTIONARY...**



NYLOGRIP Dubo Lockwasher locks and seals it-instantly!



Patents Applied For

The new NYLOGRIP Dubo Lockwasher is made of a special, cold-flow plastic called Nylon 6. When the nut is tightened, the washer "flows" — its inner diameter grips into the threads of the nut and bolt, to seal this junction against leakage, while the outer diameter flows over the outer edges of the nut, seals and locks it . . . so tight neither shock nor vibration can budge it! The Dubo Lockwasher can be used time and again without the slightest loss of holding power. And, because it's symmetrical and has no threaded parts, you couldn't fit one incorrectly if you tried.

PLUS FEATURES: excellent electrical properties . . . exceptional wear resistance . . . good shock absorption . . . resists corrosion, chemicals . . . non-flammable . . . high flexural strength.

PLUS USES: The excellent electrical characteristics of NYLOGRIP Dubo Lockwashers make them ideal for electrical insulation, or to help control electrolytic corrosion between dissimilar metals.

YOU'LL WANT COMPLETE TECHNICAL INFORMATION.

Write today to:

NYLOGRIP PRODUCTS

569 Pleasant St., Watertown, Mass.-WA 6-0100

Non Metallic Fastenings of all types.

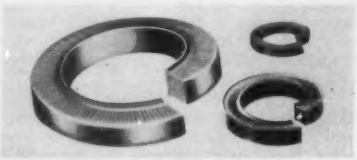
Circle F-84 on Page 97

dirt has little or no effect on indicating accuracy. Designed for use with bolts of 80,000 to 200,000 psi minimum ultimate strength where high controlled preload is required.

Materials: Alloy steel.

Sizes: No. 10 to 1½ in. nominal ID; for bolts with 125,000 to 220,000 psi minimum ultimate strength.

Source: Standard Pressed Steel Co., Jenkintown, Pa.



Rib-Type Lock Washers

Form: Helical spring lock washer with serrated teeth on both faces. Teeth imbed in the face of the nut and work to lock assembly.

Design Features: When nut is tightened, the serrations on the washer act as a lock to prevent loosening. Ribs add to washer strength and prevent distortion when nut is rotated at high speed with fast power wrenches.

Materials: Spring steel.

Sizes: No. 2 through 1½ in. nominal screw diameters.

Source: Philadelphia Steel & Wire Corp., Philadelphia, Pa.

Sawtooth Lock Washer

Form: One-piece, all-metal, spring-type washer with axial tooth projections on ID and OD. As bolt is tightened, static lock is provided by spring action and dynamic lock by grip of teeth.

Design Features: Sawtooth action provides nonslip, vibration-resistant locking action.

Materials: High-carbon steels, stainless steel, bronze, and aluminum.

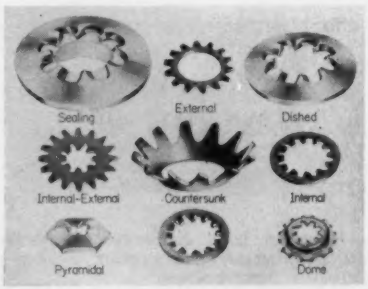
Sizes: No. 10 to ½-in. nominal screw sizes.

Source: George K. Garrett Co. Inc., Philadelphia, Pa.

Shakeproof Lock Washers

Form: Type A American Standard tooth lock washers. Under pressure of application, multiple heat-treated teeth on outer or inner, or both, diameters of washer bite into fastener and working member to provide locking action.

Design Features: Each tooth is tapered and twisted, providing spring reaction under tightening loads that resists flattening forces and loosening effect of vibration. Cushioning action also acts to protect against damage from overdriving of fastener members in assembly. Several types have been standardized. Internal type is used under small head screws (fillister, etc.) or where it is desirable to hide teeth for appearance or to prevent snagging. Heavy internal type is used with heavy bolts and nuts, and with heat-



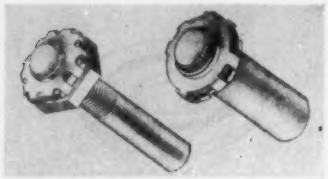
treated bolts, usually on castings and heavy machinery or equipment. External type is used with fasteners having heads large enough to contact the lock washer teeth (round, pan, binding head, etc.). Conical external type is used with flat or oval head countersunk screws. Internal-external type is used where large bearing surface is required, for oversize or elongated holes, and as an insert between adjustable members to maintain adjustment settings. Dome types, either plain or toothed periphery, are used to distribute load. They are desirable for soft or thin materials where considerable force is needed for holding. Dished types, plain or toothed periphery, are recommended for the same applications as the dome type. They should be used where resiliency rather than rigidity is desired. Pyramidal type is used for applications requiring very high tightening torques.

Materials: Hardened and tempered medium-carbon steel

Sizes: No. 2 to 1¼ in. nominal screw sizes. Size range varies for individual types.

Source: Shakeproof Div. of Illinois Tool Works, Elgin, Ill. Basic washer details for internal, external, conical, and internal-external types given in *American Standard Lock Washers*—ASA B27.1-1950.

(See Ad, Page 224)



Sta-Lok

Form: Two-piece, all-metal lockwasher assembly consists of a lugged ring nut or hex nut with a recessed groove and an internally serrated washer with tang projections. For use in bearing assemblies, the nut is torqued to the proper value, the lockwasher is aligned on the end of the shaft so that a pair of tangs fit around the lug on the nut. Washer is then driven over the shaft. The serrations cut or engage until the retaining tangs lock in place over the nut. For installation on all but large-size bolts, the serrations are formed on the bolt as the washer is pressed over the threads. With hex-head nut, the tangs extend down and over sides of nut. Several of the tangs have a 90 deg bend to snap-in and lock in the recessed groove on the nut.

Design Features: Serrations secure rotation of washer with respect to bolt while tangs prevent nut from rotating and also prevent axial movement of washer. Fatigue strength of nut bolt connection is not affected since lock is applied at top of nut.

Nut may be torqued to desired preload; backing off is not required to make washer fit since large number of serrations permits engagement in almost any position. Serrations on top end of bolt thread do not affect the thread. Washers are primarily for use in vibration assemblies.

Materials: Carbon or high-temperature alloy steels.

Sizes: For hex nuts from No. 10 to 2-in. diameter; for bearing locknuts in all common sizes of NAS and SAE series.

Source: Shur-Lok Corp., Anaheim, Calif.

Stat-O-Seal

Form: Two-piece washer unit consisting of toroidal synthetic-rubber sealant molded over inward projecting fingers of metal retainer ring.

Design Features: Dimensions of retainer ring are such that rubber sealing element is completely confined; no cold flow is developed. Positive contact of seal on four sides produces effective sealing action at high and low pressures. Metal-to-metal contact of parts is maintained for high strength. Simple washer construction eliminates need for close tolerances. Washer is reusable. Used for liquid and gas sealing of bolts and studs.

Materials: Retainer ring is steel, aluminum, and chrome-moly steel; seal is white or red silicone rubber, or one of several compositions of black nitrile rubber.

Sizes: No. 6 to 1 1/16 in. nominal ID.

Source: Parker Seal Co., Culver City, Calif.

(See Ad, Page 228)

Weath-R-Seal Washer

Form: Laminated compression washer consisting of metal backing layer bonded to resilient neoprene composition washer. When compressed by tightening of fastener, neoprene composition produces seal around outside diameter of metal backing and fastener shank.

Design Features: Washer forms watertight seal under 60 lb pressure when tightened against contact surface at recommended torque values. Cushioning action of seal is useful in reducing vibration and in protecting surface finish of parts. Shaped metal backing controls flow of neoprene composition under compression and protects it from damage as fastener is being driven. Even distribution of neoprene composition assures positive, long-life sealing effectiveness.

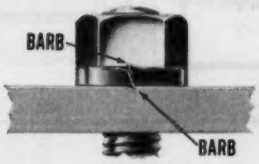
Materials: Metal backing is galvanized steel, aluminum, or 302 or 430 stainless steel.

Sizes: Standard bolt and screw sizes. OD from 3/8 to 3 in.

Source: Fabricated Products Co., West Newton, Pa.

Billy Barb says,

"HONEST! THE BARBS MAKE THE DIFFERENCE!"



Be SURE with POSITIVE

Illustration shows how NON-LINK POSITIVE Lock Washers work . . . how they combine the advantages of tooth-type washers with the proved spring-power of regular lock washers. Arrows point to the "teeth" or "barbs" embedded in both the nut and bearing surface. Combined with the spring-power of the washer itself, this feature provides *double assurance* that bolted assemblies remain permanently tight.

You can see for yourself why Positive NON-LINK Lock Washers have long been known as *one* sure way to keep bolts and nuts tight. The "barbs" or "teeth" are the feature which makes them different from and superior to conventional spring lock washers. They really hold bolted assemblies together even under severe shock and vibration.

NOW Same Price As Regular Lock Washers!

You can buy these superior NON-LINK Positive Lock Washers at the same price as ordinary spring lock washers. A new mechanized process which eliminates costly hand labor makes it possible to produce them in the 9 most popular sizes at NO EXTRA COST to you. What's more, they conform to A.S.A. standards, are non-linking and interchangeable with regular lock washers of the same size and section.

WRITE FOR SAMPLE! *If you will write us on your company letterhead, or use your company Purchase Order, we will send you a generous sample of Non-Link Positive Lock Washers in any or all of the following 9 popular sizes (Medium Section): 3/16", 1/4", 5/16", 3/8", 7/16", 1/2", 9/16", 5/8", 3/4". Just tell us which sizes you want, and the samples will be on their way, at our expense. NO CHARGE TO YOU.*

POSITIVE LOCK WASHER CO.

189 Vanderpool St. • Newark 5, N. J.

Manufacturers of High Grade Lock Washers Since 1890

Circle F-85 on Page 97

OLD
NEW
STAT-O-SEAL
LOCK WASHER
ELIMINATE
BLINDHOLES
WITH...
Stat-O-Seal
SEAL FOR STUD!
The unique design of Stat-O-Seals and their exceptional sealing effectiveness enable engineers and designers to save costs in many ways—eliminating blind holes is one of them.
Why not find out about the many plus features of Stat-O-Seals for sealing studs, bolts, other fasteners and fittings.
Write for free catalog.
Parker SEAL COMPANY
Culver City, California and Cleveland, Ohio
A DIVISION OF PARKER-HANNIFIN CORPORATION

Circle F-86 on Page 97

LOCK WASHERS

DESIGNED IN FOUR SERIES
LIGHT - MEDIUM - HEAVY - EXTRA-HEAVY
Made to ASA Specifications

Send for Catalogs on Carbon Steel and Non-ferrous washers

STANDARD LOCK WASHER & MFG. CO., INC.
17 VIKING TERRACE • WORCESTER, MASS.

Circle F-87 on Page 97

What's in a tradename?

A lot if it's the only identification you have for the answer to your fastener problem .....

The Product Directory section of The FASTENERS Book, beginning on page 96, carries an appendix which consists of an alphabetical listing of verified fastener manufacturers in the United States, coded by product category, and followed by an alphabetical listing of tradenames referenced to companies.
This might hold the key to one of your fastening problems . . . now, or sometime in the future. Here's how it works.

TRADENAME LISTING

ABACUS (A B C BOLT COMPANY)

ALL-ON (SMEDLEY RETAINING RING CO.)

AMERICASH (AMERICAN WASHER, INC.)

COMPANY LISTING

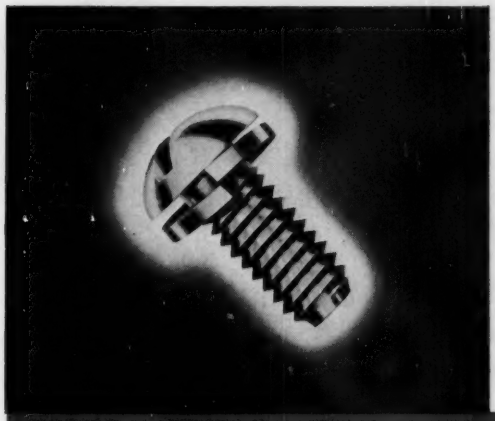
A B C BOLT COMPANY
123 BROAD STREET
ANCHOR, OHIO (N, S)—THE PRODUCT CATEGORY KEY

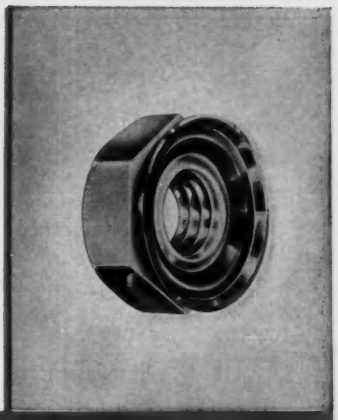
AMERICAN WASHER, INC.
459 LINCOLN BLVD.
BOOTH, MAINE (W, RI)—THE PRODUCT CATEGORY KEY

And, remember! If you want further information on any advertiser's products shown in the Directory, use a READER SERVICE CARD, Page 97.

MACHINE DESIGN

A PENTON PUBLICATION CLEVELAND 13, OHIO

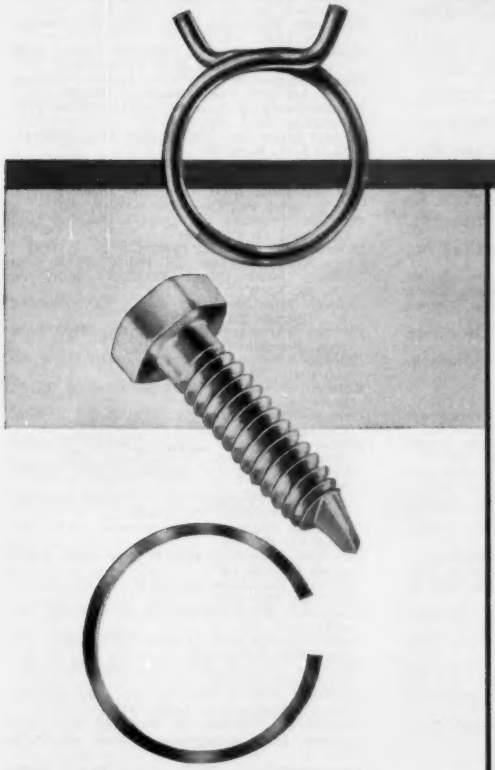




EATON-RELIANCE

FASTENERS

unseen muscles in assembled products



Because the initial cost of a fastener represents only a minor part of the total cost of "using" it in an assembly, the bulk of your fastener savings will come from these features: engineering assistance to insure use of proper fastener, ease of handling on the assembly line, stock availability and service. Metal quality, strength, vibration resistance, durability and manufacturer's reputation are also important parts of your "fastener package."

You can get all of these things by specifying Eaton-Reliance fasteners. They've been used by manufacturers of assembled products for almost half a century.

Write for our new 16 page full line catalog containing complete information.

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RELIANCE DIVISION

MANUFACTURING COMPANY

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Circle F-88 on Page 97

FASTENER MANUFACTURERS

Types of fasteners manufactured by companies appearing in this listing are classified into eight categories identified by boldface code letters:

Inserts	I	Retaining rings	RR
Nuts	N	Rivets	Ri
Pin Fasteners	P	Screws, bolts, studs	S
Quick-Operating Fasteners	Q	Washers	W

Abbott Screw & Mfg. Co., 6525 N. Clark St., Chicago 26, Ill. **(N, Ri, S, W)**

Accurate Threaded Fasteners Inc., 2901 Montrose Ave., Chicago 18, Ill. **(N, Ri, S, W)**

Acimet Mfg. Co., 1550 Rockwell Ave., Cleveland 14, Ohio **(N)**

Ackerman-Johnson Co., 652 Jackson Blvd., Chicago 6, Ill. **(I, N, S, W)**

Acme Industrial Co., 200-22 N. Laflin St., Chicago 7, Ill. **(P)**

Acme Machine Products, Div. of the Serrick Corp., Muncie, Ind. **(S)**

Adams-Rite Mfg. Co., 540 W. Chevy Chase Dr., Glendale 4, Calif. **(Q)**

Adjustable Bushing Co., 12036 Vose St., North Hollywood, Calif. **(N, P, S)**

Advance Gear & Machine Corp., 5851 Holmes Ave., Los Angeles 1, Calif. **(I, RR, S)**

Aer-O-Line Mfg. & Supply Co., 3110 Winona, Burbank, Calif. **(S)**

Aero Bolt & Screw Co. Inc., 1071 W. Arbor Vitae, Inglewood, Calif. **(S)**

Aero-Stat Co., 8021 South Western Ave., Los Angeles 47, Calif. **(S)**

Aerofast, P. O. Box 324, Wheaton, Ill. **(P)**

Aerotron Supply Co., 8504 S. Normandie Ave., Los Angeles 44, Calif. **(S)**

Air Control Products Inc., Coopersville, Mich. **(S)**

Airaterra, 620 Paula Ave., Glendale 1, Calif. **(I)**

Aircraft Bolt Corp., Subsidiary of Elastic Stop Nut Corp. of America, 543 Monterey Pass Rd., Monterey Park, Calif. **(S)**

Aircraft Radio Corp., Foonton, N. J. **(Q)**

Albany Products Co. Inc., 351 Connecticut Ave., South Norwalk, Conn. **(N, P, Ri, S, W)**

Alden Products Co., 5149 N. Main St., Brockton, Mass. **(Q, S)**

All-Form Metal Products Co., 13000 Athens Ave., Cleveland 7, Ohio **(I, P, RR, W)**

Allen Mfg. Co., Drawer 570, Hartford 1, Conn. **(N, P, S)**

Allied Products Corp., 12677 Burt Rd., Detroit 23, Mich. **(S)**

Allmetal Screw Products Co. Inc., 821 Stewart Ave., Garden City, N. Y. **(N, Ri, S, W)**

Alloway Stamping & Mfg. Co. Inc., 2507 E. 29th St., Chattanooga 7, Tenn. **(I, W)**

Alloy Socket Screw Products Co., 2942 Lakewood Ave., Chicago, Ill. **(S)**

Alton Iron Works Inc., 1205—38th St., Brooklyn 18, N. Y. **(I, N, P, RR, S, W)**

Aluminum Co. of America, 1501 Alcoa Building, Pittsburgh 19, Pa. **(N, P, Ri, S)**

Alvo Nut & Bolt Co. Inc., 1601 Grande Vista, Los Angeles 23, Calif. **(N, P, S, W)**

Amatom Electronic Hardware Co. Inc., 88 Drake Ave., New Rochelle, N. Y. **(N, S)**

American Cast Iron Pipe Co., 2930 16th St., Birmingham, Ala. **(N, S)**

American Chain & Cable Co., American Chain Div., 454 E. Princess St., York, Pa. **(P)**

American Rivet Company, Inc., 849 N. Kedzie Ave., Chicago 51, Ill. **(Ri)**

American Screw Co., Div. of Noma Lites Inc., Willimantic, Conn. **(N, S)**

American Screw Product Co., 2470 E. 93rd St., Cleveland 4, Ohio **(S)**

American Standard Products Inc., 3030 Main St., Hartford, Conn. **(I, N, P, RR, Ri, S, W)**

Amerock Corp., 4000 Auburn St., Rockford, Ill. **(Q)**

Ampco Metal Inc., 1759 S. 38th St., Milwaukee 46, Wis. **(N, S, W)**

An-Cor-Lox Div., Schnitzer Alloy Products Co., 325 Pine St., Elizabeth 1, N. J. **(N)**

Anchor Bolt & Screw Co., 2950 W. Grand Ave., Chicago 22, Ill. **(N, P, Ri, S, W)**

Anchor Fasteners, Inc., P. O. Box 2029, Waterbury 20, Conn. **(N, S, Ri, W)**

Anti-Corrosive Metal Products Co. Inc., Box 1894, Albany, N. Y. **(N, P, Ri, S, W)**

A. P. M. Corp., 252 Hawthorne Ave., Yonkers, N. Y. **(Ri, S)**

Armco Steel Corp., Sheffield Div., Sheffield Station, Kansas City 25, Mo. **(N, P, Ri, S)**

Arro Expansion Bolt Co., Box 388, Marion, Ohio **(S)**

Atlantic Steel Co., P. O. Box 1714, Atlanta 1, Ga. **(Ri)**

Atlas Bolt & Screw Co., 1120 Ivanhoe Rd., Cleveland 10, Ohio **(S)**

Atlas Tack Corp., Fairhaven, Mass. **(Ri, W)**

Auburn Mfg. Co., Pease Ave. & Stack St., Middletown, Conn. **(W)**

Austin Screw Products Co., 4873 W. Armitage, Chicago 39, Ill. **(S)**

Auto Swage Products Inc., 245 Canal St., Shelton, Conn. **(I, P)**

Auto Vehicle Parts Co., 1032 Saratoga St., Newport, Ky. **(N, P, Ri, S, W)**

Automatic Nut Co. Inc., Lebanon, Pa. **(N, S)**

Automatic Products Co., Div. American Spring of Holly, Inc., 1145 W. Grand Blvd., Detroit 8, Mich. **(N)**

Autoscrew Co., 216-222 W. 18th St., New York 11, N. Y. **(N, P, Ri, S, W)**

Avdel Inc., 210 S. Victory Blvd., Burbank, Calif. **(P, Q)**

L. J. Barwood Mfg. Co. Inc., Everett 49, Mass. **(S, W)**

Bassick Co., Div. of Stewart-Warner Corp., 3045 Fairfield, Bridgeport 5, Conn. **(Q)**

Bayonne Bolt & Nut Corp., W. Second St., Bayonne, N. J. **(P, S, W)**

Bellford Metal Products Inc., 5900 Maurice Ave., Cleveland 4, Ohio **(P, Ri, S)**

Bergen Laboratories Inc., 60 Spruce St., Paterson, N. J. **(I)**

Best Aircraft Corp., 711 Sip St., Union City, N. J. **(I, N, P, Ri, S, W)**

Bethlehem Steel Co., Bethlehem, Pa. **(N, P, Ri, S, W)**

Binder Metal Products Inc., 2940 Ramona Blvd., Los Angeles 33, Calif. **(W)**

Birnbach Radio Co. Inc., 145 Hudson St., New York 13, N. Y. **(N, RR, S, W)**

Blake Rivet Co., Div. of Spear Industries, 5030 Firestone Blvd., South Gate, Calif. **(Ri, S)**

Bland Burner Co., 83 Woodbine St., Hartford 6, Conn. **(P, Ri, S, W)**

Boots Aircraft Nut Corp., 536 Newton Turnpike, Norwalk, Conn. **(I, N)**

Brainard Rivet Co., Girard, Ohio **(Ri)**

Bremen Bearings Inc., Bremen, Ind. **(P)**

Brighton Screw & Mfg. Co., 1841 Reading Rd., Cincinnati, Ohio **(S)**

Bristol Co., 127 Bristol Rd., Waterbury, Conn. **(S)**

Brush Nail Expansion Bolt Co., Greenwich, Conn. **(I, S)**

Buckeye Forgings Co., 9217 Miles Rd., Cleveland 5, Ohio **(P)**

Buffalo Bolt Co., Div. of Buffalo Eclipse Corp., North Tonawanda, N. Y. **(N, S)**

Byrd Plastics Inc., 2953 West 12th St., Erie, Pa. **(N)**

C. E. M. Co., 24 School St., Danielson, Conn. **(P)**

C. S. M. Screw Products Co., 2105 N. Southport Ave., Chicago 14, Ill. **(S)**

Cadillac Screw Co., 826 East Madison St., Belvidere, Ill. **(S)**

California Fasteners, 4070 Hollis St., Emeryville 8, Calif. **(N, S)**

California Industrial Products Inc., 5765 Meadow Rd., South Gate, Calif. **(N)**

Camcar Screw & Mfg. Co., Div. of Textron Inc., 600-18th Ave., Rockford, Ill. **(S)**

Camloc Fastener Corp., 37 Spring Valley Rd., Paramus, N. J. **(Q)**

Central Screw Co., 3501 Shields Ave., Chicago, Ill. **(N, P, R, S, W)**

Champ-Items Inc., 6191 Maple Ave., St. Louis, Mo. **(S)**

The Champion Rivet Company, Harvard Ave. & E. 108th St., Cleveland 5, Ohio **(Ri)**

Chandler Products Corp., 1491 Chardon Rd., Cleveland 17, Ohio **(S)**

Channel Master Corp., Ellenville, N. Y. **(Ri)**

Chase Brass & Copper Co., Subsidiary of Kennecott Copper Corp., Waterbury 20, Conn. **(N, Ri, S, W)**

Chicago Expansion Bolt Corp., 1338 Concord Pl., Chicago 22, Ill. **(S)**

Chicago Hardware & Fixture Co., 9100 Park Ave., Franklin Park, Ill. **(P, S)**

Chicago Rivet & Machine Co., 9601 W. Jackson Blvd., Bellwood, Ill. **(Ri)**

Chicago Screw Co., 2701 Washington Blvd., Bellwood, Ill. **(S)**

Chicago-Wilcox Mfg. Co., 7701 South Avalon, Chicago 19, Ill. **(W)**

Circon Component Corp., Santa Barbara Municipal Airport, Goleta, Calif. **(Ri)**

Clark Bros. Bolt Co., Milldale, Conn. **(N, Ri, S)**

Clark Metal Products Inc., 75 Kings Highway Cut-Off, Fairfield, Conn. **(Ri, S)**

Clear-Cite Products, 1325 Webster Ave., Chicago 14, Ill. **(S)**

Clendium Bros. Inc., 4309 Erdman Ave., Baltimore 13, Md. **(Ri)**

Cleveland Cap Screw Co., 4444 Lee Rd., Cleveland 28, Ohio **(S)**

Coatesville Plate Washer Co., Coatesville, Pa. **(W)**

Cobb & Drew Inc., Prospect St., Box 387, Plymouth, Mass. **(Ri)**

Columbia Nut & Bolt Co., 945 Main St., Bridgeport 3, Conn. **(N)**

Columbus Bolt & Forging Co., 291 Marconi Blvd., Columbus 15, Ohio **(S)**

Commercial Shearing & Stamping Co., 1775 Logan Ave., Youngstown 1, Ohio **(N, P, S, W)**

Components Corp., 35 N. Arroys Pkwy., Pasadena, Calif. **(N, P)**

Con-Torq Inc., Subsidiary of North & Judd Mfg. Co., New Britain, Conn. **(N)**

Continental Screw Co., New Bedford, Mass. **(N, Ri, S)**

Corbin Cabinet Lock Div., American Hardware Corp., New Britain, Conn. **(Q)**

Crest Products Inc., P. O. Box 64, Union, N. J. **(N)**

Danuser Machine Co., 500 E. Third St., Fulton, Mo. **(P)**
Davis Aircraft Products Inc., 1191-5 Spofford Ave., New York 59, N. Y. **(N, P, Q)**
Decker Nut Mfg. Corp., 703 N. Clark Rd., Albion, Mich. **(N)**
Delron Co. Inc., 5224 Southern Ave., South Gate, Calif. **(I, N)**
Deutsch Fastener Corp., P. O. Box 61072, Los Angeles, Calif. **(P, Q, RI)**
Detroit-Diamond Screw Products Co., 2200 Fourth St., Wyandotte, Mich. **(N)**
Detroit Stamping Co., 350 Midland Ave., Detroit 3, Mich. **(W)**
Diamonite Product Mfg. Co., Div. U. S. Ceramic Tile Co., Shreve, Ohio **(N, P, RR, S, W)**
Dimco-Gray Co., Gray Bldg., 207 E. 6th St., Dayton 2, Ohio **(Q)**
Division Lead Co., 7742 W. 61st Place, Summit, Ill. **(RI, W)**
Driv-Lok Sales Corp., 777 Park Ave., Sycamore, Ill. **(P)**
E. I. duPont de Nemours & Co. Inc., Explosives Dept., Wilmington 98, Del. **(RI)**
Joseph Dyson & Sons Inc., 5125 St. Clair Ave., Cleveland 3, Ohio **(N, S)**
Dzus Fastener Co. Inc., 125 Union St., West Islip, N. Y. **(Q)**

Eaton Mfg. Co., Reliance Div., S. Eric & Charles St., Massillon, Ohio **(N, RR, S, W)**
Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N. J. **(N, P, Q)**
Elco Tool & Screw Corp., 1111 Samuelson Rd., Rockford, Ill. **(N, S)**
Enflo Corp., Fellowship Rd. & Rt. 73, Maple Shade, N. J. **(RR, W)**
Engman Mfg. Co., 300 New York St., Des Moines 13, Iowa **(N, S, W)**
Erie Bolt & Nut Co., 1325 Liberty St., Erie, Pa. **(N, S)**
Excelsior Hardware Co., Woodland and Mix Sts., Stamford, Conn. **(Q)**
Excelsior Leather Washer Mfg. Co. Inc., 720 Chestnut St., Rockford, Ill. **(W)**

Fabricated Products Co., 1952 Water St., West Newton, Pa. **(S, W)**
Fabristeel Products Inc., 21500 W. 8 Mile Rd., Detroit 19, Mich. **(N)**
Fasteners Inc., 161 Prescott St., East Boston, Mass. **(I, S)**
Fastener Products Inc., 239 Danbury Rd., Wilton, Conn. **(I, S)**
Federal Screw Products Inc., 3917 N. Kedzie Ave., Chicago 18, Ill. **(N, RI, S, W)**
Federal Screw Works, 3401 Martin Ave., Detroit 10, Mich. **(N, RI, S, W)**
Ferry Bros., 15300 Industrial Parkway, Cleveland 9, Ohio **(S)**
Ferry Cap & Set Screw Co., 2151 Scranton Rd., Cleveland 13, Ohio **(N, S)**
E. W. Ferry Screw Products, 5240 Smith Rd., Cleveland 30, Ohio
Fischer Special Mfg. Co., 446 Morgan St., Cincinnati 6, Ohio **(N)**
Fox Products Co., 4720 N. 18th St., Philadelphia, Pa. **(N)**
Freetown Screw Mfg. Co. Inc., R F D #1 County Rd., E. Freetown, Mass. **(RI, S)**
Freeway Washer & Stamping Co., 4911 Grant Ave., P. O. Box 1756, Cleveland 5, Ohio **(W)**

Gagnier Fibre Products Co., 10151 Capital Ave., Oak Park 37, Mich. **(W)**
George K. Garrett Co. Inc., Torresdale Ave. at Tolbut St., Philadelphia 36, Pa. **(I, W)**
General Fastener Corp., P. O. Box 608, Burbank, Calif. **(P, RI, Q)**
General Findings & Supply Co., Industrial Div., Pearl St., Attleboro, Mass. **(RI, S, W)**
General Tire & Rubber Co., Industrial Products Div., 1220 Garfield, Wabash 9, Ind. **(Q)**
John Gillen Co., 2540 South 50th Ave., Cicero 50, Ill. **(P)**
B. F. Goodrich, Aviation Products Div., Akron, Ohio **(I)**
Greatlakes Screw Corp., 13631-51 S. Halsted St., Chicago 27, Ill. **(N, RI, S)**
Greer Stop Nut Co., 2608 W. Flournoy St., Chicago 12, Ill. **(N)**
Gregory Industries Inc., Nelson Stud Welding Div., 2727 E. 28th & Toledo Ave., Lorain, Ohio **(S)**
Gries Reproducer Corp., 125 Beechwood Ave., New Rochelle, N. Y. **(N, RI, S, W)**
Grip Nut Co., 107 Broad St., South Whitley, Ind. **(N)**
Groov-Pin Corp., 1125 Hendricks Causeway, Ridgefield, N. J. **(I, P, RI)**

G W Tool & Die Co., Fort Loramie, Ohio **(S)**

Hackensack Bolt & Nut Co. Inc., 145 Bonhomme Ave., Hackensack, N. J. **(N, S, W)**
Hardware Specialty Co. Inc., 48-75 36th St., Long Island City 1, N. Y. **(I, N, P, RI, RR, S, W)**
H. M. Harper Co., 8200 LeHigh Ave., Morton Grove, Ill. **(N, P, S, W)**
Hartford Machine Screw Co., Div. Standard Screw Co., 92 Deerfield Rd., Windsor, Conn. **(N, P, S)**
The Hartwell Corp., 9035 Venice Blvd., Los Angeles 34, Calif. **(P, Q)**
William H. Haskell Mfg. Co., Pawtucket, R. I. **(N, S, W)**
John Hassall Inc., Westbury, Long Island, N. Y. **(P, RI, S)**
Heli-Coil Corp., 2 Shelter Rock Lane, Danbury, Conn. **(I)**
Hi-Shear Rivet Tool Co., 2600 W. 247th St., Torrance, Calif. **(I, N, RI, S)**
Hill Nut Co., 2620 W. Flournoy St., Chicago 12, Ill. **(N)**
Hindley Mfg. Co., Cumberland, R. I. **(P)**
Hobbs Manufacturing Co., 26 Salisbury St., Worcester 5, Mass. **(P)**
Holo-Krome Screw Corp., Div. of Veeder-Root Co., Hartford 10, Conn. **(S)**
Holub Industries Inc., Sycamore, Ill. **(I)**
Harvey Hubbell Inc., Bridgeport 2, Conn. **(S)**
Huck Mfg. Co., 2480 Bellevue, Detroit 7, Mich. **(N, RI)**

Illinois Tool Works, Calinoy Div., 12917 Cerise Ave., Hawthorne, Calif. **(Q, S)**
Illinois Tool Works, Fastex Div., 195 Algonquin Rd., Des Plaines, Ill. **(N, P, Q, RR, RI)**
Illinois Tool Works, Shakeproof Div., St. Charles Rd., Elgin, Ill. **(N, S, W)**
Independent Nail & Packing Co., Bridgewater, Mass. **(S)**
Indiana Metal Products Co., Div. of Textron Industries Inc., 919 North Michigan Ave., Chicago 11, Ill. **(S)**
Industriade Screw & Bolt Co., 2808 W. Lake St., Chicago 12, Ill. **(I, N, P, S, W)**
Industrial Nut Corp., Tiffin Ave., Sandusky, Ohio **(N)**
Industrial Plastic Fabricators Inc., Endicott St., Norwood, Mass. **(S, N, W)**
Industrial Retaining Ring Co., 57 Cordier St., Irvington 11, N. J. **(RR)**

Jacobson Nut Mfg. Corp., Box 177, Kenilworth, N. J. **(N)**
W. G. Jackson Screw Co. Inc., 6003 Beale Ct., Rockford, Ill. **(RI, S)**
Jaques Co., 69 D Batterymarch St., Boston 10, Mass. **(I, N, P, S, W)**
Walter K. Jaros Aircrafters, 48-00 Astoria Blvd., S., Astoria, N. Y. **(N, RI, S, W)**

Kaynar Co., P. O. Box 2001, Terminal Annex, Los Angeles 54, Calif. **(N)**
Kerr-Lakeside Industries Inc., 21850 St. Clair Ave., Cleveland, Ohio **(S)**
Keystone Screw Corp., P. O. Box 188, Wyandotte Rd., Willow Grove, Pa. **(I, N, P, RI, S)**
Klincher Kapscrews Inc., 2153 Hillside Ave., Indianapolis, Ind. **(S)**
Klincher Locknut Corp., 2153 Hillside Ave., Indianapolis 18, Ind. **(N)**
KSM Products Inc., Merchantville 8, N. J. **(N, P, S)**

Lake Erie Screw Corp., 13001 Athens Ave., Cleveland 7, Ohio **(S)**
Lamson & Sessions Co., 5000 Tiedeman Rd., Cleveland 9, Ohio **(N, P, RI, S, W)**
Lance Mfg. Co., 31144 W. Eight Mile Rd., Farmington, Mich. **(N, S, W)**
The E. B. Lanman Co., East Chicago, Ind. **(N, S)**
Lapeer Mfg. Co., 1144 W. Baltimore, Detroit 2, Mich. **(Q)**
Lewis Bolt & Nut Co., 504 Malcolm Ave., SE. Minneapolis 14, Minn. **(N, S)**
Lock Thread Corp., 2832 E. Grand Blvd., Detroit 11, Mich. **(I, N, S)**
Long Lok Corp., 2601 Colorado, Santa Monica, Calif. **(S)**
Lucas Aircraft Supply Co., 17311 S. Main St., Gardena, Calif. **(N, P, RI, S, W)**

Mac-It Parts Co., 275 Liberty St., Lancaster, Pa. **(S)**
MacLean-Fogg Lock Nut Co., 5535 North Wolcott Ave., Chicago 40, Ill. **(N, S)**
Marquette Bolt & Rivet Co., 8220-30 South Burnham Ave., Chicago 17, Ill. **(RI, S)**
The Maryland Bolt and Nut Co., P. O. Box 5321—Mt. Washington, Baltimore 9, Maryland **(N, S)**
Master Products Co., 6400 Park Ave., Cleveland 5, Ohio **(W)**
Maynard Mfg. Co., 22755 Shakespeare, East Detroit, Mich. **(I, N, S)**
McCormick Selph Associates, Hollister Airport, Hollister, Calif. **(S)**
McGraw-Edison Co., Line Material Industries, 700 W. Michigan, Milwaukee 1, Wis. **(N, S, W)**
McLaughlin Co., 212 Jaikens Bldg., Birmingham, Mich. **(N)**
The Mellows Co., 125 E. Nash St., Milwaukee 12, Wis. **(W)**
Mercury Air Parts Co. Inc., P. O. Box 135, 9310 W. Jefferson Blvd., Culver City, Calif. **(N, P, S)**
Mercury Screw Co., 832-840 N. Western Ave., Chicago, Ill. **(RI, S)**
H. K. Metalcraft Mfg. Co., 3775-3789 Tenth Ave. at 203rd St., New York 34, N. Y. **(W)**
Miami Rivet Co., 5677 NW 35 Ct., Miami, Fla. **(RI, S)**
Michigan Rivet Corp., 1340 E. Milwaukee Ave., Detroit, Mich. **(P, RI, S)**
Mid-Continent Screw Products Co., 5842 No. Broadway, Chicago 40, Ill. **(N, RI, S, W)**
Midwest Sintered Products Corp., 13605 South Halsted St. (Rear), Chicago 27, Ill. **(N, W)**
Milford Rivet & Machine Co., Milford, Conn. **(RI)**
Missile-Tronics Corp., 245 Fourth St., Passaic, N. J. **(I, N, P, RI, S)**
Molly Corp., 230 North Fifth St., Reading, Pa. **(I)**
Monadnock Mills, Subsidiary of United-Carr Fastener Corp., 1977 First Ave., San Leandro, Calif. **(N, Q, S)**
Monarch Cap Screw & Mfg. Co., 5906 Park Ave., Cleveland 5, Ohio **(S)**
George W. Moore, Inc., 100 Beaver St., Waltham 54, Mass. **(S)**
Moran Co., Moran Bldg., 115 Main St., El Segundo, Calif. **(S)**
J. I. Morris Co., 394 Elm St., Southbridge, Mass. **(N, S)**
Morse Products Development Co., 99 W. Walnut St., Pasadena, Calif. **(N)**
Moscow Screw Co., 701 Sand St., Waukegan, Ill. **(I, RI, S)**
Mount Clemens Metal Products Co., Fastener Div., P. O. Box 205, Mt. Clemens, Mich. **(N)**
My-T-Grip Mfg. Co., 176 Broadway, New York, N. Y. **(I)**

National Lock Co., 1902 Seventh St., Rockford, Ill. **(N, P, Q, RI, S)**
National Lock Washer Co., Sales & Market Research, Newark 5, N. J. **(RR, W)**
National Machine Products Co., 44225 Utica Rd., Utica, Mich. **(N, S)**
National Radio Co. Inc., Subsidiary of National Co. Inc., 37 Washington St., Melrose 16, Mass. **(I, S)**
National Rivet & Mfg. Co., 21 E. Jefferson St., Waupun, Wis. **(RI)**
National Screw & Mfg. Co., 2440 E. 75th St., Cleveland 4, Ohio **(N, P, RR, RI, S, W)**
National Utilities Corp., 826 S. Arroyo Pkwy., Near California, Pasadena, Calif. **(S)**
New England Bolt Co. Inc., 9 Charton St., Everett, Mass. **(S)**
New England Nut Mfg. Co., 17 Viking Terrace, Worcester 4, Mass. **(N, P)**
New England Tubular Rivet Inc., 97 Buckingham Ave., Milford, Conn. **(RI)**
New Jersey Rivet Co., 10 S. Third St., Camden, N. J. **(RI)**
Newton Insert Co., 6502 Avalon Blvd., Los Angeles, Calif. **(I, S)**
Nicetown Plate Washer Co. Inc., 1824-50 Juniata St., Philadelphia 40, Pa. **(W)**
Nielsen Hardware Corp., 770 Wethersfield Ave., Hartford 14, Conn. **(Q)**
Norrich Plastics Corp., 107-09 W. 18th St., New York 11, N. Y. **(I, N, P, S, W)**
Northwest Bolt & Nut Co., 4250—8th Ave., N. W., Seattle 7, Wash. **(RI, S, W)**
Northwestern Tools Inc., 117 Hollier Ave., Dayton 3, Ohio **(I, RR, S)**
Nylogrip Products, 447 Watertown St., Newton 58, Mass. **(N, S, W)**
Nylok Corp., 611 Industrial Ave., Paramus, N. J. **(I, N, S,)**
Nylitite Corp. of America, 280 Badger Ave., Newark 8, N. J. **(W)**

FASTENER MANUFACTURERS (Continued)

Ohio Nut & Bolt Co., 35 First Ave., Berea, Ohio (N, P, S)
Ohio Nut & Washer Co., Mingo Junction, Ohio (W)
Ohio Rod Products Co. Inc., P. O. Box 26, Berea, Ohio (S)
Olympic Screw & Rivet Corp., 11441 S. Dolan St., Downey, Calif. (RI)
Wm. H. Ottemiller Co., Pattison St. & M & P.R.R., York, Pa. (N, S)

Paine Company, 501 Westgate Rd., Addison, Ill. (N, S)
Palnut Co., Div. of United-Carr Fastener Corp., 57 Glen Rd., Mountainside, N. J. (N)
Parker-Kalon, Div. General American Transportation Corp., Clifton, N. J. (N, S)
Parker Seal Co., Div. of Parker-Hannifin Corp., 10567 Jefferson Blvd., Culver City, Calif. (RI, W)
Pastushin Industries Inc., 5651 Century Blvd., Los Angeles 45, Calif. (Q, RI)
Pawtucket Mfg. Co., Pawtucket, Rhode Island (N, S)
Peck Spring Co., Plainville, Conn. (I, N, P, RR, RI, S, W)
Peerless Automatic Machine Co., 1970 W. 77th St., Cleveland 2, Ohio (N)
Penn Engineering & Mfg. Co., W. State St., Doylestown, Pa. (I, N, S)
Penn Fibre & Specialty Co. Inc., 2024 to 2030 E. Westmoreland St., Philadelphia 34, Pa. (W)
Phelps Mfg. Div., Helicoil Corp., Danbury, Conn. (I)
Pheoil Mfg. Co. Inc., 5700 Roosevelt Rd., Chicago 50, Ill. (N, S, W)
Philadelphia Steel & Wire Corp., Penn St. & Belfield Ave., Philadelphia 44, Pa. (W)
Phillips Screw Co., 161 Prescott St., East Boston 28, Mass. (I, S)
PIC Design Corp., Div. of Benrus Watch Co. Inc., 477 Atlantic Ave., East Rockaway 1, N. Y. (S)
Pilgrim Screw Corp., 259 Dexter St., Providence 7, R. I. (S)
J. B. Pievyak Mfg. Co., 19 Jefferson St., Newton, N. J. (I)
Polyphase Instrument Co., East Fourth St., Bridgeport, Pa. (S)
Popular & Special Nut Co. Inc., 3155 Bermuda, Ferndale, Mich. (N)
Positive Lock Washer Co., Miller St. & Avenue "A", Newark 5, N. J. (W)
Precision Nut Co., 31425 Fraser Drive, Fraser, Mich. (N, RR, S, W)
Precision Rubber Products Corp., 3114 Oakridge Dr., Dayton 7, Ohio (W)
Precision Spring Corp., Peterson St., Three Rivers, Mich. (RR, W)
Premier Screw & Rivet Corp., 8124 South Hoyne Ave., Chicago 20, Ill. (RI, S)
Prestole Corporation, 1345 Miami St., Toledo 5, Ohio (N)
Producto Machine Co., 975 Housatonic Ave., Bridgeport 1, Conn. (P)
Pylon Co. Inc., Attleboro, Mass. (S, RI)

Quadriga Mfg. Co., 213 W. Grand Ave., Chicago 10, Ill. (W)
Quality Cold Heading Co., 19155 Glendale, Detroit 23, Mich. (RI, S)

Ramsey Corp., P. O. Box 513, St. Louis 66, Mo. (RR)
R. E. C. Corp., 47 Cedar St., P. O. Box 941, New Rochelle, New York (N, S)
Reed & Prince Mfg. Co., 1 Duncan Ave., Worcester 3, Mass. (N, P, RI, S, W)
REF Mfg. Corp., 393 Jericho Tpke., Mineola, N. Y. (Q)
Republic Steel Co., Republic Bldg., Cleveland, Ohio (N, RI, S, W)
Revere Screw & Rivet Corp., 1738 W. Walnut St., Chicago, Ill. (I, RI, S, W)
Rhode Island Tool Co., 148 W. River St., P. O. Box 1516, Providence 1, Rhode Island (N, S)
Richco Plastic Co., 3722 West North Ave., Chicago 47, Ill. (N, S, W)
Ring Screw Works, 22100 Sherwood Ave., Warren, Michigan (Suburb of Detroit) (RI, S, W)
Robin Products Co., 27027 Groesbeck Highway, Warren, Mich. (N, RI)
Rockford Screw Products Co., 2501 9th, Rockford, Ill. (N, S)
Rockwell Products Corp., 146 Central Ave., Newark, N. J. (N)
Rosan Inc., Rosan Bldg., Newport Beach, Calif. (I, S)
Rotor Clip Co., 116 Allen Blvd., Farmingdale, N. Y. (RR)
Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y. (N, RI, S)

Safety Socket Screw Co., 6505 Avondale Ave., Chicago 31, Ill. (P, S)
St. Louis Screw & Bolt Co., 6900 N. Broadway, St. Louis 15, Mo. (N, S, W)
Schnitzer Alloy Products Co., An-Cor-Lox Div., 193 Pine St., Elizabeth 1, N. J. (N)
J. Schwartzman Mfg. & Supply Co., 7040 Laurel Canyon Blvd., North Hollywood, Calif. (RI, S)
Scovill Mfg. Co., 100 Mill St., Waterbury 20, Conn. (Q, RI)
Screw Corp., 157 N. Rivergrade Rd., City of Industry, Calif. (S)
Screw and Bolt Corp. of America, Farmers Bank Bldg., Pittsburgh 30, Pa. (N, P, RI, S, W)
Seaboard Screw Corp., Brookside Ave., West Warwick, R. I. (S)
Seastrom Mfg. Co., 701 Sonora Ave., Glendale 1, Calif. (W)
Security Locknut Corp., 1800 N. 15th Ave., Melrose Park, Ill. (N)
J. H. Sessions & Son, 281 Riverside Ave., Bristol, Conn. (Q)
Set Screw & Mfg. Co., Bartlett, Ill. (S)
Shur-Lok Corp., 879 S. East St., P. O. Box 563, Anaheim, Calif. (I, N, W)
Siewek Tool Co., 2862 E. Grand Blvd., Detroit 2, Mich. (N, S, W)
Simmonds Precision Products Inc., Tarrytown, N. Y. (Q)
Simmons Fastener Corp., North Broadway, Albany 1, N. Y. (Q)
Solon Mfg. Co., 32301 Miles at R.R., Solon, Ohio (W)
Southco Div., South Chester Corp., Third St. & N. Governor Printz Blvd., Lester, Pa. (I, Q, S)
Southern Screw Co., P. O. Box 1360, Statesville, N. C. (N, S)
Southington Hardware Mfg. Co., Southington, Conn. (N, S)
Standard Horse Nail Corp., P. O. Box 316, New Brighton, Pa. (P)
Standard Lock Washer & Mfg. Co., 17 Viking Terrace, Worcester 4, Mass. (W)
Standard Locknut & Lockwasher Inc., 2256 Valley Ave., Indianapolis 18, Ind. (N, W)
Standard Nut & Bolt Co., P. O. Box 68 (Abbott St.), Cumberland, R. I. (N, S, W)
Standard Pressed Steel Co., Stewart Ave., Jenkintown, Pa. (N, P, Q, S, W)
Standard Screw Co., 2701 Washington Blvd., Bellwood, Ill. (N, P, S)
Stanley-Judd, Div. The Stanley Works, 43 S. Cherry St., Wallingford, Conn. (I, P, RR, S, W)
Star Expansion Industries Corp., 58 Pleasant Hill Rd., Mountainville, N. Y. (RI, S)
Star Stainless Screw Co., 699 Union Blvd., Patterson 2, N. J. (N, P, RI, S, W)
Sterling Bolt Co., 363 W. Erie St., Chicago 10, Illinois (N, RI, S, W)
Edwin B. Stimpson Co., 70 Franklin Ave., Brooklyn 5, N. Y. (RI, W)
Super Grip Anchor Bolt Co. Inc., 33 W. 22nd St., Philadelphia 40, Pa. (N, S)
Superior Mfg. Co., Inc., New Hartford Rd., Winsten, Conn. (RI, S)
Superior Wrought Washer Co., 1951 W. 90th St., Cleveland 2, Ohio (W)

T. N. F. Corp., 1052 Elizabeth Ave., Linden, N. J. (N)
Textron Inc., General Cement Div., 1818 Christiana St., Rockford, Ill. (N, RI, S, W)
Thompson-Bremer Co., Subsidiary of American Machine & Foundry Co., 520 N. Dearborn St., Chicago 10, Ill. (N, P, S, W)
Judson L. Thomson Mfg. Co., Sawyer Rd., Waltham 54, Mass. (RI)
Timber Top Inc., 38 Brooklyn Ave., Freeport, L. I., N. Y. (Q)
Tinnerman Products, P. O. Box 6688, Cleveland, Ohio. (I, N, Q, RI, S, W)
Torit Mfg., 284 Walnut St., St. Paul 2, Minn. (Q)
Townsend Co., Engineered Fastener Div., P. O. Box 71, Ellwood City, Pa. (N, RI, S)
Transit Parts Co., P. O. Box 249, 35700 Vine St., Willoughby, Ohio (N, S)
Triad Metal Products Co., 6984 Machinery Ave., Cleveland 3, Ohio (I, Q, W)
Tricon Mfg. Co., 8012 S. Wallace St., Chicago 20, Ill. (RI)
Tripiex Screw Co., Div. of Murray Corp. of America, 5319 Grant Ave., Cleveland, Ohio (N, S)
Trojan Rivet Corp., 1833 Dana St., Glendale, Calif. (RI)
Tru-Fit Screw Products Corp., 13000 Athens Ave., Cleveland 7, Ohio (S)
Tubular Rivet & Stud Co., Weston Ave., Quincy 70, Mass. (N, RI, S)
Tulsa Screw Products Co., 1055 N. Owasso, Tulsa, Okla. (S)

U. S. Chemical Milling Corp., Missile-Air Div., 1700 Rosecrans Blvd., Manhattan Beach, Calif. (Q)
U. S. Expansion Bolt Co., P. O. Box 827, York, Pa. (N, S)
Uniseal Co. of California, 8021 S. Western Ave., Los Angeles 47, Calif. (S)
United-Carr Fastener Corp., 238 Main St., Kendall Bldg., Cambridge 42, Mass. (N, P, RI, S, W)
United Screw & Bolt Corp., 3590 W. 58th St., Cleveland 2, Ohio (S)
United Shoe Machinery Corp., Pop Rivet Div., 440 Main St., West Medway, Mass. (RI)

Valley Bolt Corp. of America, 6872 Farmdale Ave., P. O. Box 3026, N. Hollywood, Calif. (N, S)
Vector Electronic Co. Inc., 1100 Flower St., Glendale 1, Calif. (N, S)
Vibra Seal Corp., 2832 E. Grand Blvd., Detroit 11, Mich. (P, Q, RR)
Vibrex Fastener Corp., Mount Kisco, N. Y. (Q)
Victor Products Corp., 2635 Belmont Ave., Chicago 18, Ill. (S)
Vlier Engineering, Wespo Div., 26935 W. 7 Mile Rd., Detroit 30, Mich. (N, Q, S, W)
Voi-Shan Mfg. Co., Div.-Voi-Shan Industries Inc., 8463 Higuera St., Culver City, Calif. (N, Q, S)
Vulcan Rivet & Bolt Corp., 1020 Pinson St., Tarrant, Ala. (N, RI, S)

Waldes Kohinoor Inc., 47-16 Austel Pl., Long Island City 1, N. Y. (N, Q, RR)
Waldick Engineering Co., Box 221, Garden City, N. Y. (P)
Waldom Electronics Inc., 4625 West 53rd St., Chicago 32, Ill. (N, S, W)
Wales Beech Corp., 2240 15th St., Rockford, Ill. (S)
Waltham Precision Instrument Co., 221 Crescent St., Waltham 54, Mass. (N)
Washers Inc., 2567 Beaufait, Detroit 7, Mich. (W)
Washington Mfg. Co., 431 N. 4th Ave., Washington, Iowa (S)
Waterbury Pressed Metal Co., P-M Nut Div., 302 Chase Ave., Waterbury 14, Conn. (N, S)
Weckesser Co., 5701 Northwest Highway, Chicago 46, Ill. (N, S, W)
Western Automatic Machine Screw Co., Elyria, Ohio (N, P, S)
Western Sky Industries, 21301 Cloud Way, Hayward, Calif. (I, N, R, S, W)
Western Wire Products Co., 1415 S. 18th St., St. Louis, Mo. (P)
Westfield Metal Products Co. Inc., Westfield, Mass. (N, S, W)
Whitso, Inc., Schiller Park, Ill. (RI)
Wilcrest Mfg. Co., 180 E. Elmwood Ave., Leonard, Mich. (RI, S)
J. H. Williams & Co., 400 Vulcan St., Buffalo 7, N. Y. (N, S)
Wilson Steel & Wire Co., 4840 S. Western Ave., Chicago 9, Ill. (RI)
Winslow Co. Inc., 701 Lehigh Ave., Union, N. J. (Q)
Wolverine Bolt Co., 9685 Grinnell Ave., Detroit 13, Mich. (S)
Wolverine Nut Co., 6556 E. McNichols Rd., Detroit 12, Mich. (N)
Wood & Spencer Co., 1930 E. 61st St., Cleveland 3, Ohio (N)
Wrought Washer Mfg. Co., 2105 South Bay St., Milwaukee 7, Wis. (W)

Yale Engineering Co. Inc., 12405 Woodruff Ave., Downey, Calif. (I, N, P, RI, S, W)
Yardley Precision Products Co., 30 E. Afton Ave., Yardley, Pa. (I)

Zimmer-Lightbody Industries Inc., 25645 Grand River Ave., Detroit 40, Mich. (N)

FASTENER TRADENAMES

For complete addresses of companies appearing in this listing, see Fastener Manufacturers, Page 230.

Acco (American Chain & Cable Co., American Chain Div.)
Acipco (American Cast Iron Pipe Co.)
Acipcoloy (American Cast Iron Pipe Co.)
Adjusto-Fit (Adjustable Bushing Co.)
Aer-O-Torq (Aer-O-Line Mfg. & Supply Co.)
Airloc (Monadnock Mills, Subsidiary of United-Carr Fastener Corp.)
Allen head (Allen Mfg. Co.)
Allenut (Allen Mfg. Co.)
Ampco 8 (Ampco Metal Inc.)
Anco (Automatic Nut Co. Inc.)
An-Cor-Lox (Schnitzer Alloy Products Co. An-Cor-Lox Div.)
Au-Ve-Co (Auto Vehicle Parts Co.)

B-Right-On (Brighton Screw & Mfg. Co.)
Ball-Lok (Avdel Inc.)
Banc-Lok (Boots Corp.)
Barclad (L. J. Barwood Mfg. Co. Inc.)
Barpad (L. J. Barwood Mfg. Co. Inc.)
Bartite (L. J. Barwood Mfg. Co. Inc.)
BB-Pin (Waldick Engineering Co.)
Bestmaid (Best Aircraft Corp.)
Blind Bolt (Hi-Shear Rivet Tool Co.)
Blind Nut (Hi-Shear Rivet Tool Co.)
Blue-Devil (Safety Socket Screw Co.)
Bolt-O-Seal (Vol-Shan Mfg. Co. Div.-Vol-Shan Industries Inc.)
Brilok (Byrd Plastics Inc.)

Cam-Bolt (Simmons Fastener Corp.)
Campbell (American Chain & Cable Co., American Chain Div.)
Cap-Captive Screw (Alden Products Co.)
Caplet (Pylon Co. Inc.)
Captive Nut (National Radio Co. Inc., Subsidiary of National Co. Inc.)
Captive Stud (National Radio Co. Inc., Subsidiary of National Co. Inc.)
Cherrylock (Townsend Co.)
Circ-O-Lox (Ramsey Corp.)
Clamp-Lock (Simmons Fastener Corp.)
Clench (J. H. Sessions & Son)
Clench-Catch (Camloc Fastener Corp.)
Clinch-it (Robin Products Co.)
Clutch head (United Screw & Bolt Corp.)
Conax (Components Corp.)
Conelok (National Machine Products Co.)
Con-Torq (Con-Torq Inc., Subsidiary of the North & Judd Mfg. Co.)
Countr-Bor (Ferry Cap & Set Screw Co.)
Crescent (Waldes Kohinoor Inc., Truarc Retaining Rings Div.)
Crest-Lok (Set Screw & Mfg. Co.)

De-Sta-Co (Detroit Stamping Co.)
Diveo (Division Lead Co.)
Dixisteel (Atlantic Steel Co.)
Dodge (Phelps Mfg. Div., Helicoil Corp.)
Dot (United-Carr Fastener Corp.)
Double/Durability (Elastic Stop Nut Corp. of America)
Double Rib (Philadelphia Steel & Wire Corp.)
Drive Stud (Groov-Pin Corp.)
Driveboit (Southco Div., South Chester Corp.)
Drive-Pin (Deutsch Fastener Corp.)
Driv-Tite (Olympic Screw & Rivet Corp.)
Dual-Lock (Simmons Fastener Corp.)
Dubo (Nylogrip Products)
Duraloe (Deiron Co. Inc.)
Dyna-Seal (Precision Rubber Products Corp.)
Dzus (Dzus Fastener Co. Inc.)

Easy Lock (Rotor Clip Co.)
Eco-Pin (Waldick Engineering Co.)
Esna (Elastic Stop Nut Corp. of America)
Everlasting (H. M. Harper Co.)
Everlock (Thompson-Bremer Co.)

Faspins (Aerofast)
Fastbolt (Vol-Shan Mfg. Co. Div.-Vol-Shan Industries Inc.)
Fastite Nut (Eaton Mfg. Co., Reliance Div.)
Fastnut (Vol-Shan Mfg. Co. Div.-Vol-Shan Industries Inc.)
Fischer Turned (Fischer Special Mfg. Co.)
Flex Nut (Prestole Corporation)
Flexloc (Standard Pressed Steel Co.)
Flite-Lok (Boots Aircraft Nut Corp.)
Fluid-Tight (Pastushin Industries, Inc.)
Flush-Lok (Set Screw & Mfg. Co.)
Full-Shear (Pastushin Industries Inc.)

GRC (Gries Reproducer Corp.)
Gask-O-Seal (Parker Seal Co.)
Gefco (General Fastener Corp.)
Gripco (Grip Nut Co.)
Gripwell (The Hartwell Corp.)

Heli-Coil (Heli-Coil Corp.)
Hex-Lok (Boots Aircraft Nut Corp.)
Hi-Clinch (Olympic Screw & Rivet Corp.)
Hi-Load (Morse Products Development Co.)
Hi-Lok (Hi-Shear Rivet Tool Co.)
Hi-Red (Holub Industries Inc.)
Hi-Thred (Parker-Kalon, Div. General American Transportation Corp.)
Hinge-Lock (Simmons Fastener Corp.)
Hoblock (Hobbs Manufacturing Co.)
Holtite (Continental Screw Co.)
Hook-Lock (Simmons Fastener Corp.)
Huckbolt (Huck Mfg. Co.)
Huglock (National Machine Products Co.)

Imex (United Shoe Machinery Corp. Pop Rivet Div.)
Inserto (Rosan Inc.)
Insulet Rivet (Pylon Co. Inc.)

J-Lok (Jacobson Nut Mfg. Corp.)
Jack Nut (Molly Corp.)
Jaro-Sair (Walter K. Jaros Aircrafters)
Jet-Lok (Boots Aircraft Nut Corp.)

Kapscrews (Klincher Kap Screw)
Kaylock (Kaynar Co.)
Keensert (Newton Insert Co.)
Kelox (Fasteners Inc.)
Keps (Shakeproof Div. of Illinois Tool Works)
Klik-Pin (Danuser Machine Co.)
Klipzon (Textron Inc., General Cement Div.)
Knu-vise (Lapeer Mfg. Co.)
Kwiko (Shur-Lok Corp.)

Lamson (Lamson & Sessions Co.)
Led-Lok (Safety Socket Screw Co.)
Life-Lok (Boots Aircraft Nut Corp.)
Link-Lock (Simmons Fastener Corp.)
Lion (Southco Div., South Chester Corp.)
Lite-Lok (Southco Div., South Chester Corp.)
Lockbolt (Townsend Co.)
Lock-O-Seal (Parker Seal Co.)
Loc-pin (Davis Aircraft Products Inc.)
Lock-tite (Continental Screw Co.)
Lockwell (The Hartwell Corp.)
Lok-Thred (Lock Thread Corp.)
Lokuts (Shakeproof Div. of Illinois Tool Works)
Long-Loc (Long Lok Corp.)
Loxit (Hobbs Manufacturing Co.)

M-F (MacLean-Fogg Lock Nut Co.)
Mac-It (Mac-It Parts Co.)
Mac-It IB (Mac-It Parts Co.)
Mc/S/A (McCormick Selph Associates)
Mil-Carb (Wrought Washer Mfg. Co.)
Mini-Mite (Set Screw & Mfg. Co.)
Min O'Dee (Lock Thread Corp.)
Missile-Air (U. S. Chemical Milling Corp., Missile-Air Div.)
Molly (Molly Corp.)
Monadloc (Monadnock Mills, Subsidiary of United-Carr Fastener Corp.)
My-T-Grip (My-T-Grip Mfg. Co.)

Neo-Bond (Atlas Bolt & Screw Co.)
Neverslip (Philadelphia Steel & Wire Corp.)
Nibscrew (Shakeproof Div. of Illinois Tool Works)
No-Mar (Pic Design Corp., Div. of Benrus Watch Co., Inc.)

FASTENER TRADENAMES (Continued)

Nu-Cup (Set Screw & Mfg. Co.)
Nutt-Shel (Standard Pressed Steel Co.)
Nylatch (The Hartwell Corp.)
Nylogrip (Nylogrip Products)
Nylok (Nylok Corp.)
Nylitite (Nylitite Corp. of America)

Offset (Set Screw & Mfg. Co.)
Oscar (Olympic Screw & Rivet Corp.)

P-K (Parker-Kalon, Div. General American Transportation Corp.)
PLF (Waldes Kohinoor Inc., Truarc Retaining Rings Div.)
PLI Washer (Standard Pressed Steel Co.)
P-M (Waterbury Pressed Metal Co., P-M Nut Div.)
P-Nut (Hi-Shear Rivet Tool Co.)
Palnut (Palnut Co.)
Panelee (Scovill Mfg. Co.)
Pawl-Loc (Deutsch Fastener Corp.)
Pem (Penn Engineering & Mfg. Co.)
Pentap (Parker-Kalon, Div. General American Transportation Corp.)
Perma-Lock (J. B. Plevyak Mfg. Co.)
Perma-Nut (Tubular Rivet & Stud Co.)
Pierce Nut (Fabristeel Products Inc.)
Pin-Grip (Star Expansion Industries Corp.)
Plasti-Grommet (Illinois Tool Works, Fastex Div.)
Plasti-Ring (Illinois Tool Works, Fastex Div.)
Plasti-Rivet (Illinois Tool Works, Fastex Div.)
Plate-Lok (Boots Aircraft Nut Corp.)
Plug Nuts (Lamson & Sessions Co.)
Point-Lok (Set Screw & Mfg. Co.)
Pop (United Shoe Machinery Corp. Pop Rivet Div.)
Pow'Rgrip (Allmetal Screw Products Co. Inc.)
Pres-Loc (Deutsch Fastener Corp.)
Press-Nut (Rosan Inc.)
Prong-Lock (Waldes Kohinoor Inc., Truarc Retaining Rings Div.)
Push-Loc (Fastener Products Inc.)
Pushlock (Whitso, Inc.)
Pushnut (Palnut Co.)

QAF (Waldes Kohinoor Inc., Truarc Retaining Rings Div.)
Q-Four (Illinois Tool Works, Fastex Div.)
Q-One (Illinois Tool Works, Fastex Div.)
QR (Illinois Tool Works, Calnoy Div.)
Q-Two (Illinois Tool Works, Fastex Div.)
Quad Rib (Philadelphia Steel & Wire Corp.)
Quickey Bolt (United-Carr Fastener Corp.)
Quick-Lock (Simmons Fastener Corp.)
Quintlock (Fox Products Co.)

Rim-Guard (Parker-Kalon, Div. General American Transportation Corp.)
Ritco (Rhode Island Tool Co.)
Riv-it (Robin Products Co.)
Rivnut (B. F. Goodrich, Rivnut Div.)
Riv-O-Seal (Parker Seal Co.)
Rollpin (Elastic Stop Nut Corp. of America)
Roll-Top (Boots Aircraft Nut Corp.)
Roto-Lock (Simmons Fastener Corp.)

Safe-T-Lok (Winslow Co., Inc.)
Saf-Lok (Safety Socket Screw Co.)
Sand-Scott (Holub Industries Inc.)
Sawtooth (George K. Garrett Co. Inc.)
Schweppe (Pheoll Mfg. Co., Inc.)
Screwgrip (Industriade Screw & Bolt Co.)
Screw-Lock (Heli-Coil Corp.)
Scrivet (National Screw and Manufacturing Co.)
Security (Security Locknut Corp.)
Sel-Lok (Standard Pressed Steel Co.)
Sems (Shakeproof Div. of Illinois Tool Works)
Serve-A-Unit Fastener (Alden Products Co.)
Setko (Set Screw & Mfg. Co.)
Shur-Lok (Shur-Lok Corp.)
Sintered (Midwest Sintered Products Corp.)
Sleev-Lock (Standard Pressed Steel Co.)
Sleev-Scru (Pylon Co. Inc.)
Slimsert (Rosan Inc.)
Snapin (Star Expansion Industries Corp.)
Snap-in (United-Carr Fastener Corp.)
Snap Nut (Prestole Corporation)
So-Hard (Southington Hardware Mfg. Co.)
Sol-A-Nut (Monadnock Mills, Subsidiary of United-Carr Fastener Corp.)
Spec-D (Air Control Products Inc.)
SPF (Camloc Fastener Corp.)
Speed Clips (Tinnerman Products)
Speed Grips (Tinnerman Products)
Speed Nuts (Tinnerman Products)
Spin-Lock (Russell, Burdsall & Ward Bolt & Nut Co.)
Spiral Cam (Dzus Fastener Co. Inc.)
Spirol (C. E. M. Co.)
Spiroiox (Ramsey Corp.)
Spred-Lok (Set Screw & Mfg. Co.)
Springin (Star Expansion Industries Corp.)
Spring-Lock (Simmons Fastener Corp.)
Springrip (Illinois Tool Works, Fastex Div.)
Springtites (Eaton Mfg. Co., Reliance Div.)
Stafast (Industriade Screw & Bolt Co.)
Sta-Lok (Shur-Lok Corp.)
Stanho (Standard Horse Nail Corp.)
Stanscrew (Standard Screw Co.)
Staps (Parker-Kalon, Div. General American Transportation Corp.)
Star-Lok (Boot Aircraft Nut Corp.)
Sta-Seal (Aer-Stat Co.)
Stat-O-Seal (Parker Seal Co.)
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Supersonic (Dzus Fastener Co. Inc.)
Swage Nut (Standard Pressed Steel Co.)
Synclamp (Timber Top Inc.)

TCF Nut (United-Carr Fastener Corp.)
Taper-Thread (Fastener Products Inc.)
Tap-Loc (Groov-Pin Corp.)
Tapit (Parker-Kalon, Div. General American Transportation Corp.)
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Tensilock (Russell, Burdsall & Ward Bolt & Nut Co.)
Tenznuts (Eaton Mfg. Co., Reliance Div.)
Threadlock (Continental Screw Co.)
Threds (Southco Div., South Chester Corp.)
Top-Seal (Fabricated Products Co.)
Torq-Loc (Bergen Laboratories Inc.)
Torq-set screw (American Screw Co.)
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Truarc (Waldes Kohinoor Inc., Truarc Retaining Rings Div.)
Tru-Lok (Waltham Precision Instrument Co.)
Tuff Tite (Townsend Co.)
Two-Way (MacLean-Fogg Lock Nut Co.)
Ty-Loc (Davis Aircraft Products Inc.)

U Nut (Vector Electronic Co., Inc.)
Unbrako (Standard Pressed Steel Co.)
Uniseal (Uniseal Co. of California)
Uni-Torque (MacLean-Fogg Lock Nut Co.)

V-Lock (United-Carr Fastener Corp.)
Versa-Rivet (Townsend Co.)
Vibrex (Vibrex Fastener Corp.)
Vi-tor (Prestole Corporation)
Vulcan (J. H. Williams & Co.)

W-Point (Parker-Kalon, Div. General American Transportation Corp.)
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Weath-R-Seal (Fabricated Products Co.)
Weg (Airaterra)
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Well-Nut (Rockwell Products Corp.)
WE-Pin (Waldick Engineering Co.)
Wempy (Westfield Metal Products Co. Inc.)
Whiz-Lock (MacLean-Fogg Lock Nut Co.)

X-Washer (Standard Locknut & Lockwasher Inc.)

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